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North-East Coast Institution of Engineers and Shipbuilders

LIEUT.-COLONEL T. EUSTACE SMITH, T.D., delivered his presidential address to the North-East Coast Institution of Engineers and Shipbuilders on Friday, October 17th, during the course of which he remarked that the last ship-repairer held office in 1929 and that the last president from the Tees was Mr. McGovern, in 1932. The work of both B.S.R.A. and Pametrada in the field of research was mentioned as being an essential feature in the structure of the industry and the president felt that full order books should not prevent experimenting with new ideas. After referring to the influence of freight rates upon shipowners, Colonel Smith went on to mention the changes in construction due to welding, and the greater welding facilities to be provided by ship repairers for the repair of such ships. The effect of the increased demand for oil upon the size of oil tankers was noted, and the president said that the great size of these ships raised questions of design and of building berths and also raised great difficulties in the ship repairing industry due to the shortage of docking accommodation and the high capital charges for providing larger docks. Turning from constructional changes, the president commented on the lack of suitable young men to assume the higher executive positions, a position caused by two major wars, the slump in 1929 and also to careers in the industry not being made attractive enough. Some leaders had been brought in from outside, but Colonel Smith felt that positions could be filled from within the industry. Existing apprenticeship schemes were satisfactory for training technicians but there was room for a higher grade of training and he thought that more University scholarships might help and that the promise of adequate pensions would be an added attraction. The president broadly reviewed the developments in apprenticeship training both in this country and abroad; he commented adversely on the regulation stipulating one day a week for technical training and underlined the difficulties caused by the needs of military service.

Institution of Mechanical Engineers' Annual Dinner

ON Thursday of last week, October 16th, the Institution of Mechanical Engineers held its annual dinner at the Dorchester Hotel, London. The toast of the Institution of Mechanical Engineers was proposed by Lord De L'Isle and Dudley, Secretary of State for Air, who remarked that our complicated modern society was becoming more than ever dependent upon the work of engineers. In particular, advancement in aeronautics was dependent upon the work of engineers. There had been startling advances in that field during the last few years. They had been brought about by close co-operation between mechanical engineers and the Service over which he had the honour to preside. The present president of the Institution had rendered distinguished services. This nation had become pre-eminent in air travel and it ought to devote itself wholeheartedly to the opportunities that lay ahead. In reply, Sir David Pye said that it was the first time in the 105 years of its existence that the toast of the Institution had been proposed by a holder of the Victoria Cross. In the last few years, the Institution had held three conferences on the development of jet engines, to which the chief experts of the world had contributed papers. The Americans had asked that certain papers from those conferences should be specially reprinted for them. During the course of his recent tour with the presidents of the Civils and Electricals to attend the Centennial of Engineering at Chicago, they had also visited Canada. Canada was a land of great promise. Canadians had the raw materials and the machinery, but they lacked skilled men. Their methods of training engineers differed from ours, and they had nothing to correspond in confering qualifications to home Institutions. Any holder of a degree could call himself an engineer. That situation was clearly disturbing Canadians. There was unfortunately an exaggerated respect for a British degree, and a failure to recognise the merits of a National Certificate Course. Turning to domestic matters, he said that the Institution's lease of its present conveniently situated premises in London ended in 1974. He was glad to announce the successful conclusion of negotiations by which the site and the building had been acquired as the Institution's freehold. Formal proceedings were brought to an end after Mr. Roebuck, vice-president, had proposed the toast of the guests and Dr. Adrian, president of the Royal Society, had responded.

Lloyd's Register Shipbuilding Returns

LLOYD'S Register of Shipping has issued its returns for the quarter ended September 30, 1952. At 343 steamships and motorships of 2,062,482 tons gross, the total showed a reduction of 13,759 tons compared with the previous quarter, and of the total 102 ships of 528,457 tons were fitting out and 241 of 1,534,025 tons were to be launched. Ships commenced during the quarter numbered fifty-two of 267,648 tons, those launched numbered sixty-one of 291,276 tons, and forty-nine ships of 266,255 tons were completed, while work was suspended on three ships of 430 tons. There were ninety-three ships, representing 645,017 tons, for registration abroad or for sale, an increase of 17,629 tons over the June quarter and 31·3 per cent of the total tonnage building in this country. Oil tankers upwards of 1000 tons numbered 100 ships of 1,149,476 tons, an increase of 18,990 tons over the last quarter, and 55·7 per cent of the total tonnage under construction in this country. Plans have been approved and material ordered for 327 ships of 2,684,263 tons, of which 61·3 per cent are oil tankers. Excluding China, Poland and Russia, the work in hand abroad reached a total of 864 ships, representing 3,802,391 tons gross, and an increase of 264,449 tons over the June quarter. During the quarter 228 ships of 974,427 tons were commenced, 212 ships of 866,892 tons were launched, 196 ships of 722,799 tons were completed and thirty-two ships of 54,371 tons were suspended. Oil tankers of 1000 tons and upwards totalled 150 ships of 1,777,498 tons, which is 331,599 tons more than in June last, and represents 46·7 per cent of the total tonnage building abroad.

"The Model Engineer" Exhibition

ON Monday last, October 20th, the twenty-seventh "Model Engineer" Exhibition was opened at the New Royal Horticultural Hall, Westminster, by H.R.H. the Duke of Edinburgh. At this exhibition, which once again shows amateur craftsmanship at its best, some 400 competition models have been submitted by model makers of all ages and from all walks of life. For many years railway locomotives and ships were firm favourites with model makers, but visitors to the exhibition will note that amateur craftsmen, particularly of the younger generation, are turning more and more to aircraft and road vehicles. These aircraft and motor vehicles, although to some eyes less attractive, are capable of spectacular performances and the design and construction of their miniature engines call for considerable ingenuity. Nevertheless, there are some fine examples of locomotives to be seen and many of the naval models are impressive both for their beautiful lines and the wealth of detail they incorporate. The variety of subjects selected by modellers for their attention seems endless, and it would appear that the more difficult and complicated a piece of equipment, machine, mechanism or building, the greater is the challenge to reproduce it in model form. Indeed, seeing some of the models exhibited this year and watching their performances, it is not easy to appreciate how so many of them were made with improvised tools and under difficult working conditions. As in previous years, a number of model making clubs are showing the results of the combined efforts of their members. A miniature motor car racing track, which has been laid down, is said to be the longest of its kind, and incorporates full scenic effects. The arena for demonstrating aircraft in flight is no longer used, but its place has been taken this year by a large water tank, in which radio-controlled model ships and other craft can be seen in operation. Until Wednesday next, October 29th, when the exhibition closes, not only those interested in model making but engineers of all kinds may take the opportunity to see this ever-popular display of craftsmanship, which is representative of the finest of its kind in this country.

Glengarnock Testing Establishment

LAST week representatives of a number of shipbuilding companies and of the technical press paid a visit of inspection to the Structural Research Establishment of the British Shipbuilding Research Association at the Glengarnock Steel works of Colvilles, Ltd. The party assembled in Glasgow at the Institution of Engineers and Shipbuilders in Scotland and travelled by bus to Largs, where the guests were welcomed by Mr. H. Wilson, a member of the council of the B.S.R.A., at an informal luncheon held in the Curlinghall Hotel. Tribute was paid to the pioneer work of Mr. J. L. Adam, C.B.E., formerly the chief surveyor of the British Corporation, who was responsible for the initial development of the tests. Afterwards, Dr. Livingston Smith, the technical director of B.S.R.A., briefly outlined the history of the testing establishment, the machines installed there and the scope of the work. The facilities at Glengarnock were originally provided to compare riveting and welding as methods of connection, and the full-scale testing of ships' structural members was instigated by the Research Committee of the Institute of Welding in 1938. Towards the end of the last war, the British Welding Research Association took over the research projects for a short period, when, in 1945, the work was placed under the control of B.S.R.A. The comparative nature of the tests was continued, but the work was extended to include tests on rolled and built-up sections and varying forms of end connections. The original machine at Glengarnock could only apply lateral loads, but B.S.R.A. has provided a second machine which can apply axial and lateral loading simultaneously. Later, the journey was resumed, and the guests visited the testing establishment to inspect the original equipment, known as No. 1 machine, and the new No. 2 machine. An aluminium alloy specimen consisting of a special section riveted to associated plating was under test in No. 1 machine, and in No. 2 machine, which was demonstrated, was a panel of plating 24ft long by 6ft wide, fitted with three stiffeners and divided into three parts by intermediate web girders.

Standardisation of Worm Gears

By W. A. TUPLIN, D.Sc., M.I.Mech.E.*

In some respects worm gears are fundamentally different from all other kinds of gear, but the British Standard worm is an involute helical gear, and it is now proposed that it should be a helical gear that can be generated by a British Standard cutter. Besides including this change, current revision of B.S. 721: 1937 (" *Worm Gears* ") *envisages a simplification of terminology, tabulation of essential dimensions of all standard worms and a section describing in detail how to determine the dimensions of standard worm gears that shall work at a specified centre distance with specified gear ratio.*

THE British Standards Institution committee charged with the revision of B.S. 721 (" Worm Gears ") recently decided that as the British Standard worm was an involute helicoid gear it should be a British Standard involute helicoid gear. This appears to be a somewhat ponderous deliberation even for a committee ! Some explanation may be desirable.

The earliest worm thread forms selected with any regard for standardisation approximated to that of the familiar Acme screw thread. It was satisfactory for worms with lead angles less than about 15 deg., but not so for worms of large lead angles because the conjugate worm wheel tooth forms were sharp pointed, or badly undercut on transverse planes offset from the central one.

A thread form that avoided these difficulties was patented by F. J. Bostock and developed with great acumen and commercial success. For obvious reasons the fact that a worm of this patented form was simply an involute helicoid gear was not mentioned either in the patent specification or in any of the subsequent publicity matter, brightly technical though much of it was. When the usual term of the patent expired, there was no object in either proclaiming or attempting to conceal the true nature of the " F. J. Bostock " worm, and it was replaced by an involute helicoid worm of different thread proportions, but of fundamentally the same nature.

The " Module System "

A system of design was developed using the " module " in inches instead of pitch as a measure of tooth spacing. This occurred in about 1926, well before the appearance of the first British Standard Specification for gearing in general, and so the possibility of making this worm identical with a British Standard involute helicoidal gear simply did not exist, nor could it be said that the use of the module was a departure from British Standard practice. On the other hand, established British practice in spur, helical and bevel gearing made little use of the " metric module " and none at all of the " inch module," and so there was no likelihood that the inch module would be adopted as standard for the commoner types of gear when formal standardisation should eventually be undertaken.

The use of the module as an indirect measure of tooth spacing has a slight advantage in arithmetical convenience when calculating diameters of spur gears without the aid of a slide rule, but in no circumstances other than these restricted ones is the module preferable to pitch, which is the natural measure of spacing.

The " module system " of worm gearing was adopted as it stood as the basis of B.S. 721 (1937) despite the fact that the use of the module was then inconsistent with B.S. 436 (1932). Worm gearing was generally regarded as a thing apart from gearing in general, and it is improbable that it occurred to anyone at the time that the adoption of a non-standard involute helicoid gear in a standard specification was hardly logical or that there was anything questionable in the use of one form of pitch measurement for one type of gear and a different form for others.

The module system of worm gearing was in itself soundly conceived (although it led to unsatisfactory thread forms in certain circumstances described by Dr. H. Walker in " Worm Gear Design," THE ENGINEER, July, 25, 1952), and not difficult to understand except in so far as its use of the module and of the " diameter quotient " were strange innovations to those who had long performed gear calculations without them. This was, however, sufficient to induce considerable reluctance to use the system, and, together with the fact that B.S. 721 (1937) did not touch the essential requirement of an engineering standard (that of fixing standard sizes) has had the result that few of the hobs made on the module system have been designed with regard to gearing requirements as a whole. Their basic dimensions (module and diameter quotient) do not fit in with any one system of rational standardisation and so the different designs, despite their number, are far from covering the field.

Standardisation of Gears

It is here desirable to notice an important difference between standards in general and gearing standards and another difference between gearing standards in general and worm gearing standards. A great virtue of standardisation is that it makes use of components which are cheap because the cost of tools is spread over large numbers. A standard rolled steel joist is cheaper than a non-standard one of the same weight because the latter would involve the expense of new rolls to produce it ; a pair of rolls can roll metal only to one section.

The case of helical gears cut by a generating process (e.g. hobbing) is different because one hob in one machine can produce any gear out of an endless variety as easily as any other. The need in helical gearing is to standardise, not gears, but cutting tools, and the essential dimensions to standardise are therefore pitches and a basic tooth form geometrically similar for all pitches.

It cannot be too strongly emphasised that while there is in general little virtue in standardising the gear tooth forms themselves, it is of great practical importance that standard gears should be capable of generation by standard cutters. For example, worm threads may be generated by a British Standard cutter, but if, as is usual, the worm threads are afterwards reduced in thickness by profile grinding, their final form is not conjugate to the British Standard basic rack. This is of no practical importance, but what is vital is the possibility of using a standard cutter for the thread-cutting operation.

Standardisation of Worm Gears

Worm gearing differs from helical gearing in that the worm wheel teeth can be economically generated only by a hob that is identical (save for certain details) with the worm that is to mesh with the worm wheel. Any one hob corresponds to only one design of worm. There must therefore be as many designs of hob as there are designs of worm and consequently economy in tool cost demands that designs of worm be standardised in the minimum number that will cover the field of practical requirements. As worms may differ from each other in axial pitch, number of threads, diameter and hand, the minimum satisfactory number of standard designs is large. It is not so large, however, as the number of different designs that have actually been used and that are yet far from satisfying all needs.

B.S. 721 (1937) standardises neither pitches nor diameters, and because of the lack of guidance for designers, the dimensions of the hobs made for " module system " worm gears bear no trace of standardisation in the useful sense. Abandonment of the module system could not be resisted on the plea that all requirements were covered by the large stock of tools made on that system. Introduction of a new standard is never intended to imply that existing tools should be scrapped ; all it need mean is that no new tools should be made to old designs except where it is necessary to produce replacements that must be identical with their predecessors.

The possibility of creating a true standard for worm gearing without restriction to comply with any detail of B.S. 721 (1937) has opened up attractive possibilities in rationalisation and simplification for the average user of the standard.

Selection of Thread Form

The first step in considering the revision of B.S. 721 (1937) was to confirm that the British Standard worm should be an involute helicoid gear. There was no reason to do otherwise as the involute helicoid form is the simplest possible one in design, manufacture and measurement ; only in rare circumstances does any other form show operational superiority and the difference is never great.

The next obvious step was to specify that the British Standard worm, being an involute helicoid gear, should be capable of generation by a British Standard involute helicoid gear cutter. (This does not preclude the cutting or grinding of worm threads by other methods.) Worms are extreme cases of involute helicoid gears and it was necessary to confirm that there was no geometrical fact that would prevent their threads from being generated by standard cutters. This having been done, there was no real reason for standardising a thread form of any other sort. There were some mild objections to this step, which is at once rational and advantageous to production, but only on the ground that the ratio of thread thickness to worm wheel tooth thickness (not at all a critical matter) would not have quite the same arbitrary value as in the module system.

Adoption of this principle means that the threads of standard worms of certain types may be generated on existing hobbing machines with standard hobs. The dimensions of some standard worms are such that no standard hobbing machine could generate their threads economically, but that is no reason for rejecting the thread form that has that possibility in other cases. Lack of advantage in some circumstances is no cause for forswearing it in others. Every process

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for cutting or grinding involute helicoid worm threads can handle a British Standard thread form as well as any other.

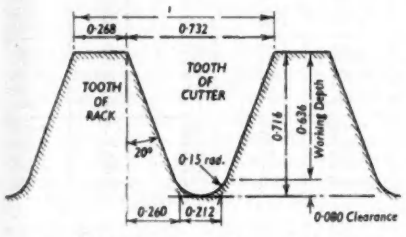
In certain worms it is necessary to use a working depth less than standard. Such worms are usually called "topped" worms and are discussed later. Their threads may be generated by a standard cutter.

The form of the British Standard basic rack is shown in Fig. 1, with the largest possible fillet radius at the root. The depth of tooth exceeds that of the old "Brown and Sharpe" standard tooth, which was 0·686 times the pitch, but the large fillet radius of the British Standard tooth leaves it with an advantage in permissible load for a given maximum root stress.

The stiffness of the worm shaft against bending is only very slightly reduced by the reduction in root diameter associated with the large root fillet radius of the British Standard thread, as only a small fraction of the total length of the worm is directly affected.

Method of Specifying Pitch

In general British gearing practice, the pitch of teeth is usually specified either directly or by the equivalent "diametral pitch." The only advantage of the alternative is that it enables diameters of spur gears to be calculated mentally, but for no other kind



The teeth of a B.S. rack-type generating cutter fit into the spaces between the teeth of the basic rack.

Fig. 1—Normal Section of British Standard Basic Rack

of gear does the same facility apply. It seems desirable to specify the spacing of teeth by the natural method of quoting the distance between them, accepting that calculation of diameters will involve π; that is no particular hardship when a slide rule is used, and for this purpose no procedure is superior. An involute helicoid gear has two fundamental pitches, the normal base pitch which is that of the basic rack conjugate to the threads, and the axial pitch which is arbitrary.

Working on the British Standard system, the normal base pitch is the cosine of 20 deg. multiplied by the standard normal pitch of the basic rack. For the convenience of referring to the standard pitches rather than to the corresponding base pitches, the worm is said to have a normal pitch that is equal to that of the British Standard basic rack to which its threads are conjugate. The nominal normal pitch of the worm is the normal pitch on the cylinder at which the normal pressure angle is 20 deg. (The normal pitch on any other cylinder is different.)

Method of Specifying Diameter of Worm

It is conventional to specify the diameter of a gear as that of a "pitch circle." This is far from satisfactory, because :

(*a*) The term "pitch circle" has a variety of interpretations.

(*b*) No involute gear has a pitch circle (as usually defined) until it is meshed with another gear.

(*c*) No worm has a pitch circle (as usually defined) even when meshing with its mating worm wheel.

(*d*) No pitch circle is directly measurable except in the rare cases when it happens to coincide with the tip circle or root circle.

When considering how the diameter of a worm might best be defined, simplicity suggested that it should be the one diameter that must in any case be specified before manufacture can start, and that is the outside diameter ("blank diameter" or "tip diameter"). Unlike pitch diameters, the outside diameter can be measured directly on the gear blank or (not quite so easily if the number of threads is odd) on the finished or partly finished gear.

The pitch diameter of generation, the pitch diameter of engagement and the nominal pitch diameter have their uses when tooth contact is being analysed, but that had been done long before the new draft standard was considered, and pitch diameters would serve no more useful purpose in the standard itself than would a table of involute functions.

Instead of the equation,

Centre distance = ½ (pitch diameter of worm + pitch diameter of worm wheel),

we now write :

Centre distance = ½ (outside diameter of worm + throat diameter of worm wheel) − (working depth of thread).

The proposal to make this substitution at first caused consternation in the committee, but there can be little doubt of the advantage of relating the important dimension of centre distance to directly measurable diameters on the gears instead of to imaginary ones.

Worm Size

The term "worm size" is a tentative one denoting the ratio of outside diameter of the worm to the normal pitch. The worm size of any worm is the outside diameter of the geometrically similar worm with unit normal pitch.

This term is an occasional convenience rather than a necessity and it may be deemed superfluous.

Axial Pitch of Worm

With a given number of threads, a given axial pitch and a standard normal pitch, the outside diameter of the worm may have any value within a range determined by the necessity for avoiding sharp-crested threads on the one hand, and undercut threads on the other. Conversely, if the outside diameter, number of threads and normal pitch of basic rack are fixed, the axial pitch may have any value within a certain range. This flexibility is used in the latest proposals to specify axial pitches (in the 1in to 2in range) that are all conveniently factored multiples of 0·01in so that selection of change gears to give the lead motion in worm thread cutting and grinding machines can be effected exactly and without recourse to "continued fractions" or any alternative procedure for finding approximating fractions.

Designation of Standard Worm

A standard worm (in the system now proposed) is completely defined by :

Outside diameter, d_a.
Number of threads, t.
Axial pitch, p_a.
Normal pitch (of conjugate B.S. basic rack), p_n.
Hand (right or left).

A standard worm can be identified from measurements made by a steel rule. (From normal pitch, as approximately measured, and the outside diameter, determine the worm size. In the table of dimensions of worms of the known number of threads and and worm size, find the one that has the measured axial pitch).

Throat Diameter of Worm Wheel

A worm wheel with T teeth to mesh with a given worm may have any throat diameter D_t that is less than

$$\frac{1}{\pi}\left[Tp_a+\left(4-\frac{15}{T}\right)p_n\right]$$

and greater than

$$\frac{1}{\pi}\left[Tp_a+\left(1+\frac{25}{T}\right)p_n\right] \quad \ldots \quad (1)$$

(This implies that T shall not be less than 14).

Additional Dimensions Required in Manufacture

(a) *Worm.*

Working depth of thread = $0{\cdot}636p_n$, except that for a "topped" worm the value is $0{\cdot}586p_n$.

Total depth of thread (and of worm wheel tooth) = working depth + $0{\cdot}08p_n$.

Root diameter, $d_r = d_a - 2\times$ total depth of thread.

Desirable minimum face width $f_p = 4p_a$.

Lead $L = tp_a$.

Lead angle at mid-depth λ_m derived from

$$\tan\lambda_m = \frac{2tp_a}{\pi(d_a+d_r)}.$$

The caliper settings for the worm are:—

Height h = $0{\cdot}4p_n$ (or $0{\cdot}35p_n$ for topped worm).

Thickness $g = 0{\cdot}557p_n$ − (reduction by grinding).

(b) *Worm Wheel.*

Outside diameter $D_a = D_t + 0{\cdot}4p_n$.

Root diameter $D_r = D_t - 2\times$ total depth of tooth.*

Maximum useful face width $F = \sqrt{[p_n(2d_a - p_n)]}$.

(c) *Centre distance.*—

$$C = \tfrac{1}{2}(d_a + D_t) - \text{working depth of thread} \quad \ldots \quad (2)$$

Base Diameter of Worm

A useful method of checking the profile of an involute helicoidal worm thread is to compare it with a straight-edge set tangentially to the base cylinder and inclined to transverse planes at the base lead angle λ_o. For this purpose it is necessary to know the value of

Base diameter

$$d_o = \frac{t}{\pi}\frac{p_a p_n \cos 20\text{ deg.}}{\sqrt{(p_a^2 - p_n^2\cos^2 20\text{ deg.})}}.$$

Base lead angle λ_o is derived from

$$\tan\lambda_o = \frac{tp_a}{\pi d_o}.$$

These are the only dimensions required in drawing and producing the gears, and they involve no concept more specialised than those of diameter and pitch. Once a standard worm has been selected for a particular job, subsequent calculation is straightforward and the normal accuracy of a standard 10in slide rule suffices for it.

Standard Worms

The present proposal is that the outside diameter and axial pitch should be tabulated for every standard worm with a normal pitch between 1in and 2in. There is a geometrically similar series of worms with normal pitches between 2in and 4in, another between ½in and 1in, another between ¼in and ½in, and so on. For a worm in the first-mentioned range of normal pitch, the designer simply copies dimensions from a table ; for a worm

* The total depth of the worm wheel tooth may be less than the standard figure by any amount up to $0{\cdot}05p_n$, and this may be advantageous in permitting a greater crest width on the teeth of the worm wheel generating hob.

in any other range he multiples tabulated dimensions by 2 or divides by 2, 4, &c.

In B.S.I. 721 (1937) no specific dimension is given, but instead there are formulæ from which dimensions may be determined by inserting the selected values of module and diameter quotient. In principle this is simple enough, but in industrial practice it is far less attractive than copying figures from a list. Presentation of actual dimensions of all standard worms is the strongest possible inducement against inventing non-standard ones.

Determination of Sizes of Standard Worms

The ideal worm to mesh with a worm wheel of specified number of teeth is the one of smallest diameter consistent with acceptable deflection under load. The magnitude of the deflection depends on the root diameter of the worm and on the span of its bearings; the minimum possible value of the bearing span depends on the diameter of the bearings and the diameter of the worm wheel. The maximum "acceptable" deflection is dependent on the resultant shift of contact bearing area on the worm wheel teeth and is not easy to define.

After making some rational assumptions in conjunction with examination of dimensions of a large number of designs of worms in use, it was found that a reasonable smallest standard size of worm is one with outside diameter equal to 2·9 times the normal pitch of the basic rack. Such a worm must be made solid with its shaft and the worm wheel must not have more than about fifty teeth if the deflection is to be acceptable under full load with the minimum practicable bearing span. The smallest size of a worm capable of being bored to accommodate a shaft of adequate diameter has outside diameter equal to about 4·1 times the normal pitch. Thus, two "worm sizes," 2·9 and 4·1 were fixed, and between them two sizes, 3·3 and 3·7 are proposed. Above 4·1 two other sizes, 4·5 and 5·0 may be desirable.

Some committee members thought it unnecessary to have so many standard worm sizes, while others were equally certain that some intermediate ones would also be required. A compromise would be to retain the series, 2·9, 3·3, 3·7, 4·1, 4·5, 5·0, and to specify an additional "sub-standard" series, 3·1, 3·5, 3·9, 4·3, 4·75, for use where special restrictions prohibit the application of a standard size. The principle is to encourage designers to use standard worms wherever possible but, for coping with unusually difficult cases, to give sub-standard sizes instead of leaving complete freedom of choice.

In determining standard sizes, it was, of course, necessary to ensure that the worm threads would in no case be either sharp crested or undercut. In certain circumstances this double requirement demands that the depth of the thread be less than standard, and this is effected by "topping" (see later).

Selection of Standard Pitches

Because the throat diameter of a worm wheel of a given pitch and number of teeth may have any value within a certain range, it is possible to design worm gears for any centre distance whatever on the basis of standard worm sizes and a limited number of normal pitches. To do this it is necessary that the normal pitches should be spaced in steps of about 5 per cent. Neither the standard "inch size" pitches nor the "diametral pitches" are so closely spaced as this, but the combination of the two (fifteen pitches between 1·000in and 2·000in) very nearly closes all the gaps. The left-hand column in Table I shows the pitches (in the range 1in to 2in) upon which the present proposals are based; an additional pitch between 1·875in and 2in will probably be found necessary.

The principle is to make full use of standard pitches of the two established types rather than to standardise pitches that do not fit into any existing system.

"Topped" Worms

If the ratio of depth of thread to normal pitch has the British Standard value, certain worms (with mid-depth lead-angles approximating to 45 deg.) have threads with undesirably small crest width. This can be avoided, without departing from the possibility of generation by a British Standard cutter, either by "topping" or by "shallow cutting."

In effect, topping consists of cutting threads to full standard depth in a standard blank, and then reducing the outside diameter of the worm until the threads have adequate crest width. (In practice, of course, the blank is machined to the required reduced diameter to start with.) The resulting worm departs from the general standard only in having a smaller outside diameter; in the new proposals, the difference is $0{\cdot}1p_n$ in every case, although in some instances a smaller difference would suffice for the purpose. The working thread depth of a "topped" worm is 7·9 per cent less than standard.

The other alternative is a worm of standard outside diameter, but with threads of less than standard depth by an amount that suffices to leave adequate crest width. The disadvantage of this scheme is that, for any particular crest width, the depth of thread is less than that of the corresponding "topped" worm.

The necessity for exceptional worms is unfortunate, but is avoidable only by adopting the thread depth of the topped worm as standard for all worms. This, however, would artificially reduce the load capacities of most worms and so would be an unjustifiably high price to pay for the mere avoidance of a few exceptions.

The inclusion of topped worms in the series causes no difficulty to the designer as the outside diameters of such worms are tabulated like all the others, but with a special note that the height setting of the thread-gauging caliper is $0{\cdot}35p_n$ instead of $0{\cdot}4p_n$.

Number of Standard Worms

For worms with every number of threads up to ten and with every standard normal pitch between 1in and 2in, the present proposals envisage the listing of 570 designs (1140 including right-hand and left-hand alternatives).

The same number of designs is required for complete coverage of each other range of pitch and has occasioned some alarm because of its apparent extravagance. It must be emphasised, therefore, that:

(*a*) All but a small proportion of total requirements are covered by about half the total number of designs.

(*b*) Most requirements are covered by about a quarter of the total number of designs.

(*c*) Many of the designs are unlikely to be required at all, but must be listed so that the field shall be covered.

(*d*) Even the total number of designs envisaged is smaller than the number of unco-ordinated designs already used.

(*e*) Failure of the system to cover the field would leave gaps that would eventually be occupied by unco-ordinated designs greater in number than an ordered system would require.

It is thought essential to provide for all requirements because a designer who finds that the British Standard makes no provision for some particular application of worm gearing may tend to ignore the specification altogether. If standardisation of worm gearing is to become fully effective, every designer must be convinced that there is a British Standard worm for every job.

Table I—*Five-Thread Worms* ($t=5$)
Gives Axial Pitch and Outside Diameter of Standard Worms

Normal pitch, p_n	Worm size, d_{a1}									
	3·2		3·7		4·1		4·5		5·0	
	p_a	d_a	p_a	d_a	p_a	d_a	p_a	d_a	p_a	d_a
1·000	1·38	3·209*	1·24	3·692	1·17	4·066	1·12	4·534	1·089	5·030
1·0472	1·45	3·352*	1·30	3·860	1·22	4·296	1·18	4·663	1·14	5·267
1·125	1·56	3·597*	1·40	4·133	1·32	4·548	1·26	5·101	1·23	5·550
1·1875	1·65	3·791*	1·47	4·394	1·38	4·898	1·33	5·384	1·29	6·038
1·250	1·74	3·985*	1·55	4·615	1·46	5·100	1·40	5·668	1·36	6·300
1·3125	1·82	4·197*	1·62	4·877	1·53	5·378	1·47	5·952	1·43	6·583
1·375	1·90	4·408*	1·70	5·096	1·60	5·655	1·54	6·234	1·50	6·845
1·4375	2·00	4·585*	1·78	5·317	1·68	5·859	1·62	6·400	1·568	7·138
1·500	2·08	4·796*	1·86	5·537	1·75	6·135	1·68	6·801	1·64	7·400
1·5708	2·18	5·019*	1·95	5·790	1·83	6·444	1·76	7·114	1·71	7·900
1·625	2·25	5·201*	2·01	6·019	1·89	6·690	1·82	7·368	1·77	8·175
1·6875	2·34	5·396*	2·09	6·240	1·98	6·828	1·89	7·652	1·84	8·438
1·75	2·43	5·589*	2·17	6·460	2·04	7·170	1·96	7·935	1·909	8·700
1·796	2·49	5·743*	2·22	6·659	2·09	7·375	2·01	8·162	1·96	8·926
1·875	2·60	5·995*	2·32	6·942	2·19	7·650	2·10	8·501	2·04	9·455

* "Topped." Caliper height setting, $h=0{\cdot}35p_n$

Worm Wheel Generating Hobs

It will be noticed that the efforts towards standardisation of worm gears have been concentrated almost entirely on the worms. It must be emphasised again, however, that this is only because a worm wheel generating hob must correspond with the mating worm and because it is valuable to minimise the number of designs of hobs. Strictly speaking, the standardisation is applied to the hobs rather than to the worms, and it is only because it is normal practice to make or to buy a worm wheel generating hob to correspond to a previously specified worm that standardisation is applied to worms. Because of its cost, the hob is the master of the situation, and when a designer selects a standard worm he does so with the knowledge that either the corresponding hob already exists, or, if it has still to be made, will be one of a series selected to cover all practical requirements with the smallest possible total number of hobs.

Worm Wheels

There is no object in applying strict standardisation to worm wheels, as a wide variety of them (differing, for example, in number of teeth) may be generated by a single standard hob. All that the specification need give are formulæ for face width and for the

range of diameter permissible for any number of teeth cut by any standard hob.

Modified Worm Wheels

The extent and location of the area swept by the contact lines on a worm wheel tooth are affected by small changes in the relative positions of worm and wheel. For an application in which this kind of variation may be important, it is a recognised practice to generate the worm wheel teeth by a hob that is not an exact counterpart of the worm. The necessary small differences between worm and hob must usually be determined by trial and correction. As the dimensions of the worm are, in normal practice, precisely stated on the working drawing, any necessary adjustments are usually made to the hob, which may be, in consequence, non-standard.

Taking the broad view, which recognises that it is more valuable to standardise the hob than the worm, this procedure is not ideal. It is preferable to use a standard hob and to modify the worm as found necessary to secure the desired result in contact conditions. Not only does this maintain standardisation where it is the more valuable, but it also has the advantage that it is easier to modify a worm than to modify the corresponding hob.

The main objection to the rational procedure is a non-technical one. It is that the precise dimensions of the worm cannot be determined until at least one example has been made and tried; this may upset a nicely planned production programme.

For this reason the conventional procedure may be preferred in cases where the number of identical worm wheels to be cut is large enough to reconcile the manufacturer to the cost of a non-standard hob that has no general utility. Non-standard hobs should clearly be avoided wherever possible and for this reason any necessary departure from standard should be made to the worm rather than to the hob.

Design Problems

A standard specification is not normally expected to give instruction on design and it is unjust to criticise a specification (e.g. B.S. 721 : 1937) because it does not do so. Nevertheless, worm gearing, long treated as a specialist's preserve, is a fitting subject for exception, and it is intended that the revised form of B.S. 721 shall contain information from which the appropriate standard worm for a contemplated application of worm gearing can be determined as easily by the tyro as by the expert.

This has been facilitated by the omission of all superfluous terms and concepts from the specification itself. The system now proposed avoids the pitfalls that beset the path of a designer who treats every design problem on first principles as if it were the only one of its class. The design procedure is reduced to a simple routine that is at once easier and safer for the designer who is not a gearing specialist than attempting any detailed geometrical analysis.

A chart gives (for any desired ratio and centre distance) the number of threads, worm size and ratio of axial pitch to normal pitch of the appropriate standard worm. The number of teeth in the worm wheel is then determined by multiplication and from it the range of throat diameter and of centre distance for $p_n=1$ follow immediately. By simple proportion, the range of p_n for the required centre distance is quickly obtained, and usually there is a standard pitch in that range. Selection of a standard pitch and calculation of detail dimensions are then straightforward.

These basic data on the selection of worm size are derived from the practice of several worm gear manufacturers of long experience, and the procedure is presented in a way that avoids any need for experience in the calculator himself. Even a practised designer can advantageously use cut-and-dried procedure for handling a routine problem, as it saves time, reduces the risk of errors and, where standard worms are concerned, leads to the same result as the most carefully pursued analysis.

The avoidance of specialised terminology, the reduction of everything to the utmost simplicity and the inclusion of unambiguous instructions on design are parts of a policy of encouraging engineers to take full advantage of the specification by making it easier to use it than to do without it.

Numerical Example

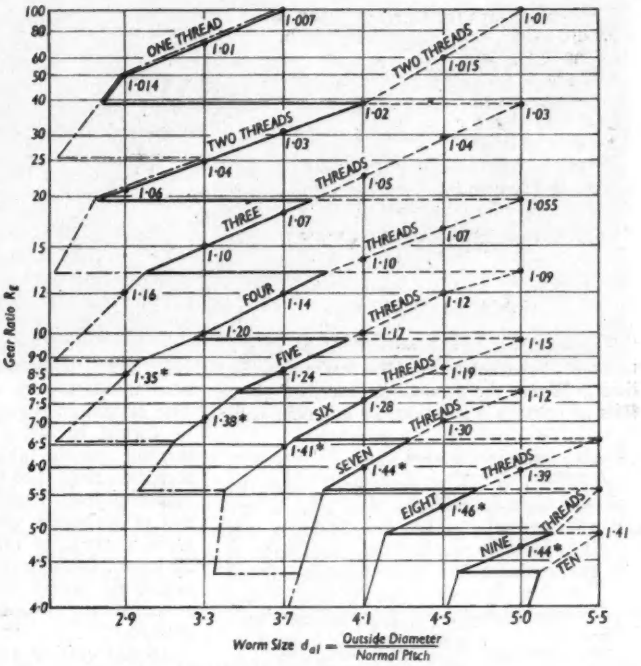
Let it be required to determine the dimensions of standard worm gears, ratio 8·5 to 1 (±3 per cent) to work at 11in centre distance.

The first step is to determine the dimensions of the "basic worm" for which $p_n=1$ and which is geometrically similar to the required worm. Fig. 2 gives the recommended number of threads, worm size and p_{a1} $(=p_a/p_n)$ for any gear ratio after location of the intersection of the horizontal ratio line and one of three oblique lines, each of which represents a number of threads.

(*a*) For normal service, with centre distance 3in to 17in, the heavy oblique line is used with either of the adjacent oblique lines as a reasonable alternative.

(*b*) For normal service with centre distance greater than 17in, the dotted line is used.

(*c*) For normal service with centre distance less than 3in, and for automobile rear-axle service, the chain-dotted line is used.



Approximate value $p_{a1}=\frac{\text{axial pitch}}{\text{normal pitch}}$ for each combination of worm size and number of threads is noted at the intersection of the corresponding vertical and oblique lines.

This chart gives number of threads, worm size and approximate ratio of axial pitch to normal pitch of the standard worm appropriate to any specified gear ratio.

* Topped worm.

Fig. 2—Selection Chart

The worm size (d_{a1}) is the number of the vertical line immediately to the right of the intersection of the ratio line and the appropriate oblique line.

In this case, $d_{a1}=3\cdot7$ and $t=5$.

The value of p_{a1} is shown at the intersection of the vertical line corresponding to the worm size and the oblique line corresponding to the number of threads.

In this case it is 1·24.

The number of worm wheel teeth $T=t\times$ratio, or $T=5\times8\cdot5=42\cdot5$, say 43.

The limits of normal pitch p_n are given by

$$\frac{2\pi C}{\pi d_{a1}+Tp_{a1}-15/T},$$

and

$$\frac{2\pi C}{\pi d_{a1}+Tp_{a1}+25/T-3}.$$

In this case the numerical values are :

$$p_n=\frac{2\pi\times11}{\pi\times3\cdot7+43\times1\cdot24-15/43}=1\cdot059$$

and

$$p_n=\frac{2\pi\times11}{\pi\times3\cdot7+43\times1\cdot24+25/43-3}=1\cdot11.$$

From Table I (the list of standard five-thread worms) it is seen that no standard pitch lies between 1·059 and 1·11, and so it is necessary to make some change in the assumed figures. The easiest change is to write $T=42$, whereupon the limits of p_n become 1·09 and 1·13.

This range contains the standard pitch 1·125, and, accepting this, Table I shows that the standard five-thread worm for which $d_{a1}=3\cdot7$ and $p_n=1\cdot125$ has dimensions $p_a=1\cdot40$ and $d_a=4\cdot133$.

The working depth for $p_n=1\cdot125$ is $0\cdot636\times1\cdot125=0\cdot715$.

Since $C=\frac{1}{2}(d_a+D_t)$—working depth, the throat diameter of a worm wheel to mesh with this worm at 11in centre distance is :

$$D_t=2C-d_a+2\times\text{working depth} \quad . \quad . \quad . \quad (3)$$

$$=2\times11-4\cdot133+2\times0\cdot715=19\cdot297.$$

To check the calculation, it should be confirmed that this value lies between the limits for a worm wheel with 42 teeth meshing with a worm with $p_n=1\cdot125$ and $p_a=1\cdot4$. These limits are :

$$\frac{1}{\pi}\left[Tp_a+\left(4-\frac{15}{T}\right)p_n\right]=\frac{1}{\pi}(42\times1\cdot4+3\cdot642\times1\cdot125)=20,$$

and

$$\frac{1}{\pi}\left[Tp_a+\left(1+\frac{25}{T}\right)p_n\right]=\frac{1}{\pi}(42\times1\cdot4+1\cdot595\times1\cdot125)=19\cdot3$$

and this confirms that 19·297 is acceptable. (The deficiency of 0·003in is negligible.)

It may be noted that the dimension particularly associated with the meshing of the gears at the specified centre distance is calculated from (3), which involves only multiplication by 2, addition and subtraction, operations which can be quickly and precisely performed without mechanical aid.

The essential dimensions of standard gears that satisfy the specified requirements are therefore :

Worm :

Number of threads t $=5$.
Outside diameter d_a $=4\cdot133$.
Normal pitch p_n $=1\cdot125$.
Axial pitch p_a $=1\cdot40$.
Minimum desirable face width $=4p_n=4\cdot5$.

Lead $=tp_a=5\times1\cdot40=7\cdot00$.

Working depth of thread $=0\cdot636p_n$
$=0\cdot636\times1\cdot125=0\cdot715$.

Total depth of thread=
Working depth $+0\cdot08p_n=0\cdot805$.

Root diameter :

$d_r=d_a-2\times$ total depth
$=4\cdot133-1\cdot610=2\cdot523$.

$$\tan\lambda_m=\frac{2\times5\times1\cdot4}{\pi(4\cdot133+2\cdot523)}$$
$$=0\cdot67,$$

whence

$\lambda_m=33°\ 48'$ (used only for angular setting of hob or milling cutter ; not critical to 5').

Caliper Settings for worm:

Height h $=0\cdot4p_n=0\cdot45$.
Thickness $g=0\cdot557p_n=0\cdot627$
(before grinding).

Worm wheel :

Number of teeth T $=42$.
Throat diameter D_t $=19\cdot297$.
Outside diameter D_a $=D_t+0\cdot4p_n$
$=19\cdot75$ (to nearest $0\cdot01$).

Maximum useful face width $=\sqrt{[p_n(2d_a-p_n)]}$
$=\sqrt{(1\cdot125\times7\cdot141)}=2\cdot83$.

$D_r=D_t-2\times$ total depth
$=19\cdot297-1\cdot61=17\cdot687$.

This example is a borderline case in that the throat diameter is at the lower specified limit. Where the procedure described above fails to provide a solution, an adjacent value

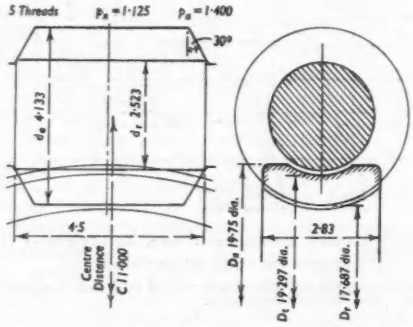


Fig. 3—Dimensions of Worm Gears 5/42 Ratio at 11in Centre Distance

of t (in the above case either 4 or 6) may do so. Should the alternative also fail, the original value of t may be tried in conjunction with a different worm size, e.g. $d_{a1}=4\cdot1$ instead of $3\cdot7$.

General

The numerical example worked out here shows how simply the essential dimensions of standard worm gears may be determined on the system now proposed. The design procedure demands nothing more than defined steps in arithmetic with no reliance on skill or judgment in the calculator. This is possible because the number of standard worms is limited and the number that might be used to meet any particular design requirement with economy and efficiency is not usually more than two. With proper guidance a newcomer to the subject can pick out the best standard worm for a job with the same certainty (and almost the same speed) as can a worm gearing expert.

So far as purely technical matters are concerned, utilisation of standard worms is easy enough, but in practice it may be necessary to pay attention to other considerations, such as, for example, one mentioned by Dr. H. Walker.

Economical manufacture of worm gears for fitting into standard units requires that all worms for any size of unit must have diameters within a narrow range, generally to avoid limitations set by adjacent components in the final assembly. Similarly, the outside diameter of the worm wheel must be the manufacturer's standard figure for the particular size of gear unit.

In preparing designs for a new series of standard worm gear units, there would be no difficulty in using British Standard worms exclusively in conjunction with a fixed size of worm wheel blank for each size of unit.

It may not be possible to fit every manufacturer's standard worm gear dimensions into the proposed B.S. scheme or, indeed, into any one scheme at all. This, however, is just an example of the temporary difficulty that occurs upon the introduction of almost any standard ; the standard products of some at least of the various manufacturers do not comply with it and the discrepancy persists until some convenient opportunity arises for falling into line. Standards are guides for the present and the future ; they do not enjoin immediate scrapping of equipment.

Second European Machine Tool Exhibition, Hanover

No. II—(*Continued from page* 512, *October* 17*th*)

WE continue our description of some interesting machine tools which were displayed at the Second European Machine Tool Exhibition, which took place in Hanover from September 14th to 23rd.

S. Eustacchio

The firm of Stabilimenti di S. Eustacchio S.A., of Brescia, Italy, showed one of its heavy boring and turning mills. This double-column machine, as shown in Fig. 5, has two tool heads on the adjustable cross rail, and a side head on the right-hand column. Its 13ft 5½in diameter table is designed to accommodate work weighing up to 29½ tons. The maximum diameter of work which can be turned is 14ft 11in and 7ft 2½in when turning over the table with the tool heads on the cross rail. The drive is by a 65 h.p. d.c. variable-speed motor, which, without the use of elaborate gearing and control gear, gives a range of table speeds from 0·5 to 20 r.p.m. through push-button control. An automatic speed control system maintains a constant cutting speed with varying diameters.

Thread cutting and taper turning devices are also fitted. The headstock at the ends of the cross rail has a simple speed change gearbox giving three speeds. Preselection within these speed ranges is effected through an electro-mechanical gear operated by push buttons. The main control panel is mounted on a pedestal in front of the machine, from which point there is an unobstructed view of machining operations. The special equipment available includes a slotting device, which can be fitted to one of the tool heads on the cross rail, and a drilling and boring attachment can also be provided if required. The illustration clearly shows the robust columns and cross rail which, with the substantial base, form a closed frame. The adjustable cross rail is automatically clamped to the columns in any position by means of clamping blocks operated by a motor with push-button control.

The weight of the boring mill with two tool heads on the cross rail is 90 tons, and the weight of the side head with its separate controls is 10 tons, giving a total of 104 tons for the complete unit together with the full electrical equipment.

H. A. Waldrich G.m.b.H.

On the stand of H. A. Waldrich G.m.b.H., of Siegen, Westphalia, which is represented in this country by Alfred Herbert, Ltd., of Coventry, there was shown one of the smallest

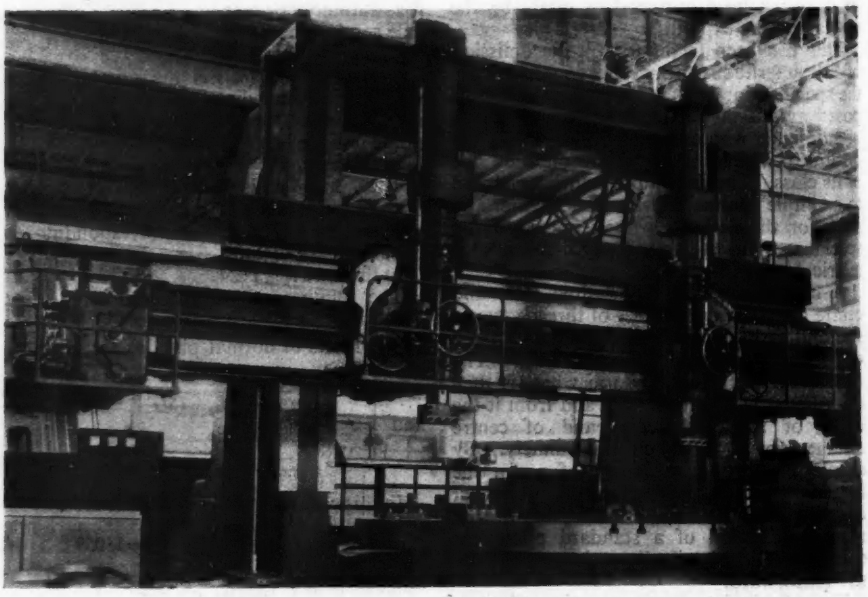


Fig. 5—Double Column Boring and Turning Mill—Eustacchio

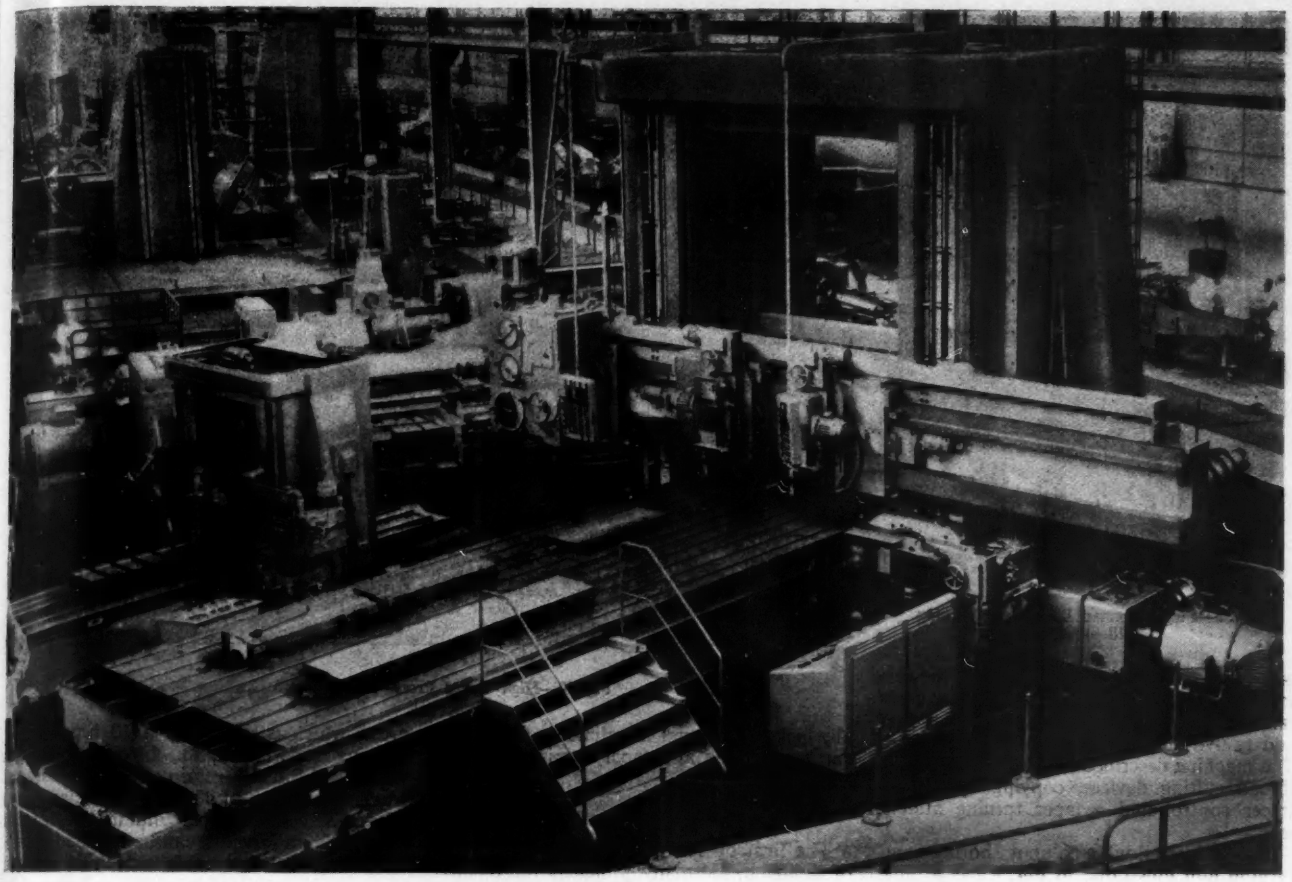


Fig. 6—Large and Small Double Column Planing Machines—H. A. Waldrich

planing machines built by the firm and one of the largest. These machines are shown in Fig. 6. The small machine, which weighs 33 tons, has a planing width of 4ft 2in, with a similar planing height, and a planing length of 10ft. The large machine, weighing some 250 tons, is designed both for heavy-duty planing and milling and has a planing width of 10ft 6in and planing height of 9ft 10in, with a planing length of 26ft 3in.

In the rigid frame the heavy top member is carried right across the two side columns, which are firmly attached to the foundation plate. The method of clamping the cross rail on the side supports has been improved. The new design of tool-box, having a vertical lift, is particularly useful when machining difficult work in which little room remains for the runout of the tool. In Fig. 7 we show the planing of a tee slot with the new tool-box. The makers state that by raising the tool vertically it is possible to machine such a slot without stopping the planer, and that the work can be done in considerably less time than normally required.

Each of the tool heads is independently driven. A worm rack is arranged at the back of the tool-box on the lower side of the upper face, and the gear system is accommodated in the space between the two guideways. A variable-speed Ward-Leonard controlled motor drives a worm which engages the rack. A two-speed remote control gear is also provided, which can be operated from either the control desk or the pendant control stations. The vertical motion is given by bevel pinions, and it is stated that very fine adjustment is possible with this new arrangement used in conjunction with an appropriate gauging system. The milling head can be seen to the left of the machine on the cross rail.

In addition to the machines already mentioned, Waldrich also displayed examples of its special lathes for steel works, particularly for the turning and grinding of rolls. They included a high-speed lathe with 28in centre height and a roll turning lathe with a 16in centre height, also an ingot milling machine. The beds of these lathes are provided with steeply sloping chip outlets of large section, which deliver the chips by channels to an underground collecting pit, from which the chips can either be continuously removed by a conveyor belt or by crane. Alternatively, the chip outlets can be arranged in the rear wall of the bed, so that they can be removed by hand shovelling or by conveyor belts. The saddle and tailstock of each of these heavy lathes are carried on separate sets of slideways, and the use of duplicate ways for the grinding head and tailstock has also been adopted on a new roll grinder. The ingot milling machine, which was shown, is of special interest to makers of high-grade alloy steels, for it enables the four sides of an ingot to be milled quickly and economically so that any faults are easily detected. The copying method employed uses the workpiece itself as the pattern for the machining of the four faces.

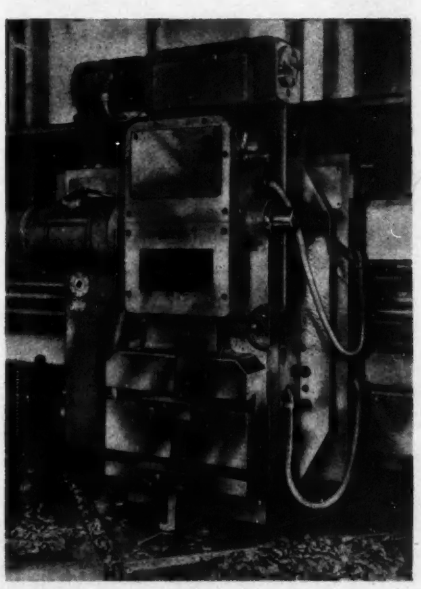


Fig. 7—Planer Tool Box with Vertical Lift—H. A. Waldrich

Froriep G.m.b.H.

Maschinenfabrik Froriep G.m.b.H., of Rheydt, Rhineland, showed new designs of single and double-column vertical boring and turning mills. The firm is represented in England by B.E.L.A. Machine Tools, Ltd., of 90, Victoria Street, London, S.W.1. An improved design of horizontal boring, drilling and milling machine was also exhibited. In Fig. 8 we illustrate the smaller machine, which is an improvement on the machine exhibited at Hanover last year. The speed range of the table has been increased and the operation of the machine greatly simplified.

The machine is one of a series of six and it has a table diameter of 4ft 1in, the range of speeds being from 3·6 to 180 r.p.m. The table drive is by a helical toothed gear rim meshing with the pinion of a vertical shaft driven by bevel gears. The drive gearbox which gives eighteen table speeds, is controlled by a knob on the lower control pendant, and speed changes can be effected whilst the machine is working or at rest. Switches on the control pendant also operate the main motor, the starting, stopping, and braking of the table, and the movements

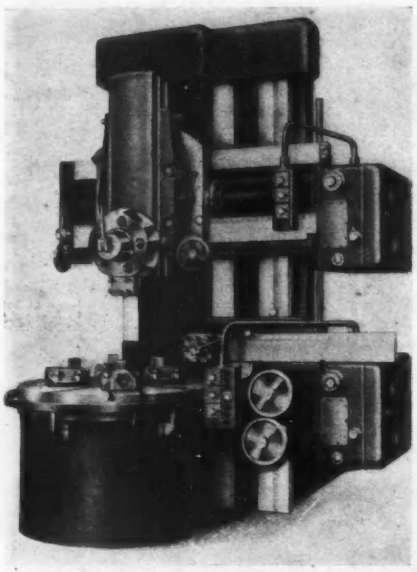


Fig. 8—Single Column Boring and Turning Mill—Froriep

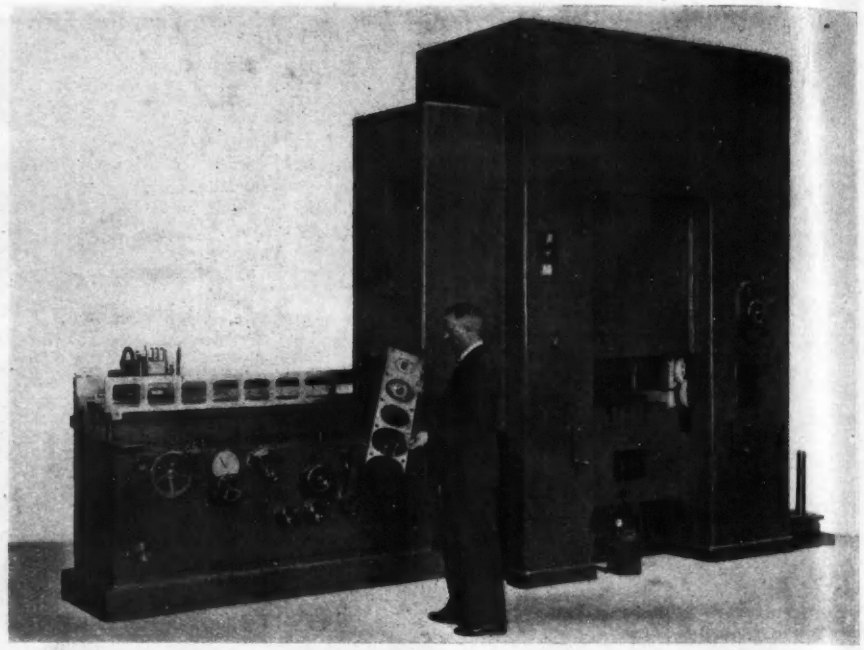


Fig. 10—High-Speed Press—L. Schuler A.G.

and feeds of the side arm. A lever for fine motion control is also provided. The cross rail slide is controlled from the upper pendant and twelve rates of feed can be preselected. The machine described can be supplied with thread cutting devices, copying by electric tracer control and a taper turning attachment.

The larger double-column boring and turning mill illustrated in Fig. 9 has a table diameter of 11ft 6in. The machine is designed for working with carbide-tipped or high-speed steel tools, and its table has a range of twenty-one speeds from 0·5 to 50 r.p.m. A constant cutting speed device is also fitted. The sixteen rates of feed provided for the tool heads are set by adjusting a preselection knob on the feed boxes and subsequently pressing a push button, and the cross rail is hydraulically locked. Special attachments for thread cutting, copying and taper turning can also be fitted.

Th. Kieserling and Albrecht

The firm of Th. Kieserling and Albrecht, of Solingen, Germany, which is represented in this country by Mr. F. W. Kubach, of 12, Sylvan Road, London, S.E.19, showed examples of its products including several presses and a centreless bar turning machine. We have chosen for illustration (see Fig. 11) the firm's "P.A.U." high-speed automatic blanking press, which has been designed for producing blanks, formed and pierced from strip material, at high output rates. The press, which is driven by a 10 h.p. motor, running at 1430 r.p.m., through infinitely variable "P.I.V." gearing, has a designed working pressure of 40 tons, with a range of 80 to 370 strokes per minute. Material up to 200mm in width can be handled by the press. The slotted table, which is 500mm in length, with a width of 505mm, is provided with a passage hole 300mm by 190mm. The ram is guided by four adjustable pillars, adjustable slides being fitted to take up lateral pressure. Drive is transmitted through a combined multi-disc clutch and brake housed within the flywheel and operated by compressed air. The press can be operated either with safety two-hand control or, for normal continuous work, with push-button control. The conveniently-grouped controls are arranged at the front of the press. The machine has high-speed rollers at the exit to compensate for stretching of the strip and to maintain correct tension. A scrap shearing device is fitted; it is adjustable in height to bring it up to a convenient position.

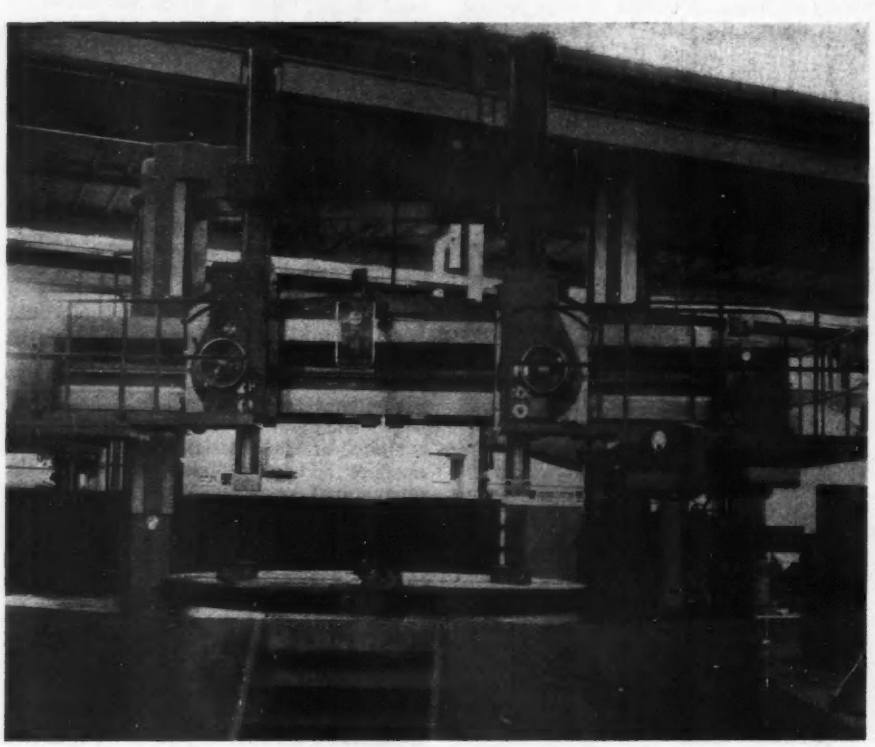


Fig. 9—Double Column Boring and Turning Mill—Froriep

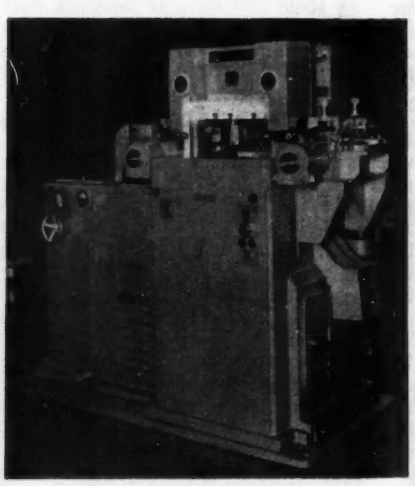


Fig. 11—High-Speed Automatic Blanking Press—Kieserling and Albrecht

L. Schuler A.G.

On the stand of L. Schuler A.G., of Goppingen, Wurtemberg, a variety of presses

and shearing machines were shown. The press illustrated in Fig. 11 is a double-sided high-speed unit with the drive arranged in the head of the machine. This machine is one of a series specially designed for the production of laminations for rotors, stators, transformers, &c. A similar machine was shown at the Machine Tool Exhibition at Olympia by Pearson Philips, Ltd., of 194/196, Finchley Road, London, N.W.3, who represents L. Schuler A.G. in this country. The press has a working pressure of 80 tons, and a fixed stroke of 1in. Ram speeds up to 500 strokes per minute are possible with the machine, and its design includes a double-sided roller feed with the exit rollers running faster than the entry rollers to compensate for the lengthening of the strip during blanking. The feed rate of the press can be set with a hand-wheel while the machine is running. A stacker receives and stacks the blanks as they come from the die to facilitate their removal. The scrap cutter can be set to cut at each stroke of the ram or at predetermined intervals.

MASCHINENFABRIK WEINGARTEN A.G.

An interesting exhibit on the stand of Maschinenfabrik Weingarten A.G., of Weingarten, Wurtemberg, was the screw press illustrated in Fig. 12. It combines a direct electric drive with pneumatic control and is suited for both hot and cold pressing operations. Machines up to 180 tons working pressure have a rigid one-piece body of special quality cast iron, and larger presses are built up of steel castings with uprights reinforced by hot-inserted steel tie-rods. The cast steel ram is actuated by a special bronze worm-screw nut, driven by a stainless steel worm screw keyed to the flywheel which is carried on ball and thrust bearings in the head of the press. The flywheel rim has a series of V-shaped grooves and a pinion on the motor, arranged vertically at the back of the press, engages with the inner sides of the grooves. A compressed air-operated brake, with magnetic control, is also fitted within the flywheel. The stroke of the ram and its striking force is adjustable over a wide range by electrical means, a scale being fitted to show the stroke. A two-hand safety control gear, which works on the balance-beam principle, gives protection against possible accidents. When needed, a simple form of ejector can be fitted to the press. One of the very large presses shown on the Weingarten stand demonstrated a "light curtain" protective device. The optical rays generated by the system cover the whole of the space between the press columns—8ft 6in—and anything passing through the "light curtain" so formed, immediately brings the press to a standstill. This device can be supplied either to protect one or both sides of a press, and a mirror is provided which enables the rays to be tilted through an angle of 15 deg. in either direction, without impairing the efficiency of the protection given.

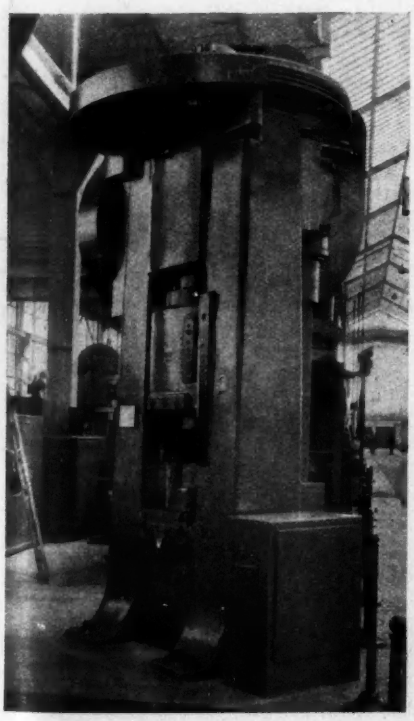


Fig. 12—Percussion Screw Press—Maschinenfabrik Weingarten A.G.

LUDWIG VON ROLL'SCHEN EISENWERKE A.G.

The firm of Ludwig von Roll'schen Eisenwerke A.G., of Berne, Switzerland, which is represented in England by Lancing Machine Tools, Ltd., of Lancing, Sussex, exhibited a recent example of its new precision forging machines. This machine, illustrated in Fig. 13, has been designed to deal with round work pieces, but special machines and attachments are available for polygonal shapes, and splined shafts.

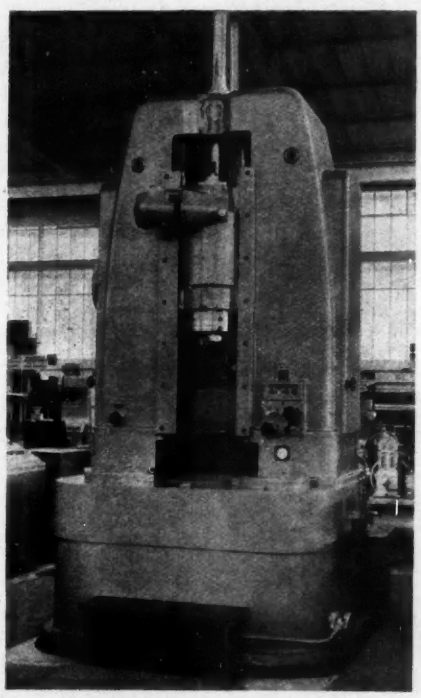


Fig. 13—Precision Forging Machine—Ludwig Von Roll'schen Eisenwerke

The vertical upper part of the machine carries an air-operated chuck which grips the work piece, rotates and feeds the billet into the swaging and forging tools arranged in the lower part of the machine. The forging box contains three fast-running eccentric shafts which transfer their motion to guided connecting-rods on the swaging tools. The shafts are arranged at 120 deg. The hydraulic control is operated from the front of the machine, and it varies the radial setting of the forging hammers, according to the diameter of the work, as well as the vertical movement or stroke of the air-operated chuck, thereby co-ordinating the diameters and lengths of each stage of the forging operation. A throttle valve is used to regulate the speed of forging between limits of 1in and 6in per minute. A maximum reduction of about ¼in on the diameter can be effected in one minute. The dimensional accuracy of the machine is said to approach that of rough turning or milling. The designed forging pressure of the machine illustrated is 100 tons, and it handles work up to a maximum diameter of 3½in. With one set of tools the maximum reduction in diameter at one operation is about 1¼in. Chucks with diameters of 3½in to 4in are available.

(To be continued)

Diesel Digestion

ON Thursday, October 16th, Mr. G. B. Fox delivered his presidential address at a general meeting of the Diesel Engine Users' Association. It took the form of a paper with the title "Diesel Digestion," the intention being to cover all those parts of a diesel engine concerned with the digestion of fuel.

In the course of it Mr. Fox said that early experiments during the first world war concerned blast injection engines and those of solid injection common rail design which were used for the propulsion of submarines, lack of high-pressure fuel pumps limiting the development of the latter. The volumetric efficiency was reasonable but the fuel was not finding some 50 per cent of the available air, and atomisation was experimented with, early troubles being caused by the effect on penetration by increasing air density. The author went on to recall air-assisted injection and also the progress made in blast injection between 1920 and 1930 which, in conjunction with a suitable combustion chamber, resulted in a clean exhaust up to 130 m.i.p. For speeds up to 500 r.p.m., the piston indicator proved satisfactory, but for higher speeds the Farnboro indicator was used. Diagrams showed that conditions for fuel digestion were correct when the initial rise of the pressure line of the diagram (90 deg. out of phase) crossed the T.D.C. line at about half way. The slope of this "line of vitality" alters when any part of the system is not functioning correctly.

A section of the paper touched upon pilot injection and upon thermal efficiency and mechanical losses as illustrated by experiments concerning the effect of reducing the cylinder pressure, using lubricating oils of varying viscosity, and of belt lubrication. Another factor mentioned was the design of the combustion chamber which must be charged with the maximum of fresh air which must not escape past piston rings. The proper functioning of these also contributes to good combustion and the pressure behind the top ring has great influence on liner wear, as has also the maximum cylinder pressure. The latter was confirmed in an experiment with a high-pressure air compressor delivering at 3500 lb per square inch, in which cast iron spring rings were worn out in 30 hours, while uncut rings of aluminium alloy lasted for 500 hours with practically no wear. Experience with various forms of rings was described in the paper and although unconventional patterns had advantages, straight-sided rings gave good service. Aluminium alloy pistons, it was stated, have high thermal conductivity and emissivity and can withstand high temperatures for long periods while in the event of a seizure there is little damage to the liner. However, this conductivity raises the temperature of the top ring, an important consideration since this temperature generally limits the power developed. The paper mentioned that the more important part of the combustion chamber was the piston head, the shape of which was governed by the combustion aspect and also by the heat flow and thermal stresses. Several drawings included in the paper illustrate piston development from early uncooled designs to cooled aluminium alloy pistons; while others show liner temperatures and the temperatures recorded for a steel head piston compared with those of an aluminium alloy piston.

THE CANAL AND POWER STATION OF THE DONZERE-MONDRAGON PROJECT

Power Station Structure From Downstream, April 1952

Power Station, Spillway and Lock From Upstream, April 1952

Andre Blondel Power Station on the River Rhone

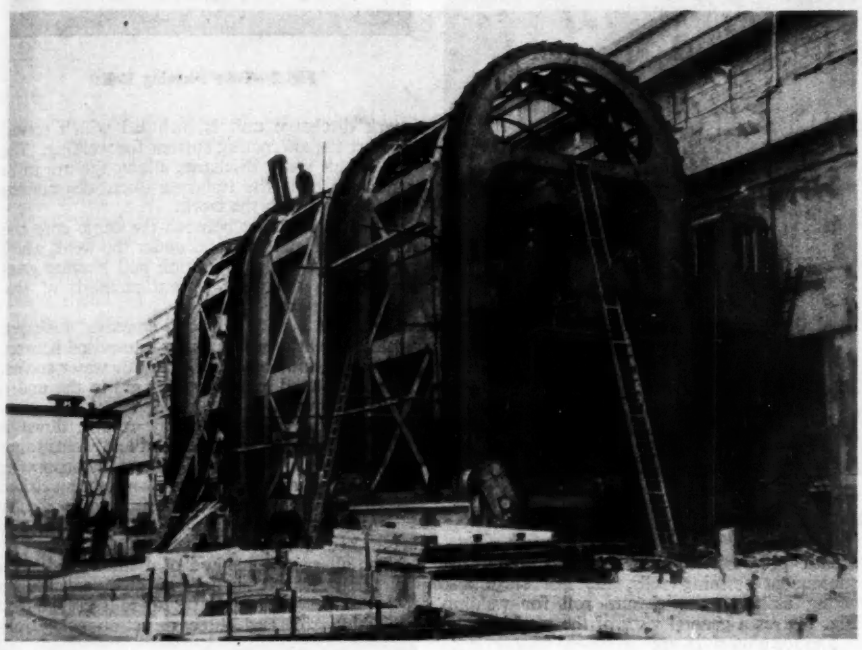
The Donzere-Mondragon hydro-electric and navigation scheme on the River Rhone is to be opened by the President of the French Republic, Monsieur Auriol, tomorrow. It has been designed by the Compagnie Nationale du Rhone and is one of the most ambitious civil engineering projects ever undertaken in Western Europe.

THE illustrations on the opposite page show the André Blondel power station of the Compagnie Nationale du Rhone, which is now nearly complete. It is one of the largest hydro-electric power stations in Europe, and forms part of a combined navigation and power development—the Donzere-Mondragon project—on the lower Rhone. The scheme has already been described in some detail in these columns, in the last two parts of an article devoted to the development of the River Rhone generally,* so that some brief notes only are given here, to illustrate the progress which has since been made.

Briefly, the Donzere-Mondragon project consists of a barrage across the Rhone at Donzere with intake works for power and navigation above it, leading to a canal with a length of 28km along the left bank. Some 17km from the canal intake is the combined power station, lock and spillway structure illustrated herewith. The power station will eventually have six 50MW Kaplan turbo-alternator sets installed in it, with a head of about 23m, operating on base load to generate almost 2000 million kWh annually. At present four sets are being installed; their position, as well as the position of the two sets to be put in later on, can be clearly seen from the illustrations. Next to the power station, and forming part of the same structure, there is a spillway, with six sluice gates at the level of the head race canal invert, each pass having a capacity equal to the flow of a single turbine. There is then a lock working over a maximum range of 26m.

Since the spring, the initial tests of the new installations have been carried out, and the first two turbo-alternator sets have already supplied more than 100,000kWh to the French grid; the canal has been open to navigation since the beginning of July. We are informed that the somewhat novel designs adopted for filling and emptying the lock and for the lock gates have functioned perfectly, and in operation a maximum instantaneous rise in level of 4·8m per minute has been obtained, with a mean rise of about 3m per minute. The lock gates have functioned satisfactorily, but the downstream gate gear has been strengthened to give greater safety; the strengthened winch cables allow the gate to be lifted in two minutes with one winch.

Apart from its exceptionally large size, the Donzere-Mondragon project is of interest on account of a number of technical advances which have been embodied in it. In fact, the experience gained in its design and construction will form the basic technique for future schemes on the lower Rhone. In each part of the project some unusual problem had to be solved. At the barrage across the Rhone, sector gates of exceptionally large span were used because of the foundation conditions. At the intake works the design includes a novel method of preventing the entry of coarse material rolled down by the river. In the canal itself, apart from the great quantity of excavation involved, studies were carried out to control the water table, to ensure watertightness in the head race canal, and to use silt for constructing embankments rapidly and on a large scale. At the power station it was necessary to ensure that surges in the canal would not take place in the case of an interruption in the transmission line circuit. The unusual design of the lock and the great height over which it works has already been mentioned.



Transporter Unit for Turbine Inlet Gates

Our third illustration shows the rail-mounted transporter unit used to lift and carry the turbine inlet gates. Each turbine has three inlet openings, each of which can be closed by a roller gate. When the gates are raised they articulate to take up the circular shape of the top of the transporter unit, on which they rest. There is only one set of three gates, and one transporter unit to lift or lower them or carry them to the particular turbine concerned. The reasons justifying the use of only one set of gates for all six turbines were given in the second part of our previous article. The transporter unit may also be seen in the illustration showing the upstream side of the power station.

* THE ENGINEER, Dec. 8, 15, 22 and 29, 1950.

Modern Signalling Constructional Practice

AT a meeting of the Permanent Way Institution, on Wednesday, October 22, 1952, Mr. O. S. Nock, chief draughtsman of the Westinghouse Brake and Signal Company, Ltd., read a paper on "Design and Constructional Features of Some Modern Signalling Installations from the Viewpoint of Permanent Way Men." The author described first how the concentrated nature of the light beam from modern colour light signals made it necessary to design structures for minimum deflection where cantilevers were concerned; reference was made to riveted and welded designs, and the concrete brackets recently put into service on the Southern Region.

With power-operated points, whether all-electric or electro-pneumatic, a very "clean" and simple arrangement can be devised for single turnouts, with all apparatus in the 6ft way; but many cases arise with slip roads, movable diamond crossings, double leads, and so on, where the application of power working needs considerable ingenuity to secure a neat arrangement. Reference was also made to the practice of bringing into service power-worked points in advance of the general change-over, by installing temporary electric circuit controllers on the old mechanical locking frames.

Permanent way men are very much aware of the cabling arrangements in connection with modern signalling. Sometimes it is carried at ground level in wooden trunking, sometimes buried, using armoured multi-core cables, and sometimes carried on stump lines alongside the track. Particular reference was made to the very carefully-designed layouts of cabling on the surface lines of London Transport Executive. The author stressed the importance of good design of cable layout in large modern signal boxes, and showed a series of illustrations in the mezzanine below the operating room in the box at York. Associated with cabling was the importance of having apparatus readily removable for maintenance purposes, and the development of relays and other equipment with detachable terminal boards was described.

Electricity Consumption in September

PROVISIONAL figures published by the British Electricity Authority show that the sales of electricity over the country as a whole, in September, 1952, were 8 per cent higher than in September, 1951. However, making allowance for the number of working days and the weather (September, 1952, being the coldest September since 1931), the national increase is found to be only 2·5 per cent. A year ago the position was very different, for the corrected September figure for 1951 was 8·5 per cent higher than that for 1950.

The effect of the weather conditions last month are reflected in the following figures of the percentage increases recorded by the Area Boards when comparing September, 1952, with September, 1951: London, 11 per cent; South Eastern, 12·2 per cent; Southern, 17·1 per cent; South Western, 10·6 per cent,; Eastern, 12·3 per cent; East Midlands, 9·2 per cent; Midlands, 10 per cent; South Wales, 5·6 per cent; Yorkshire, 11·6 per cent; North Eastern, 3·4 per cent; South East Scotland, 10·4 per cent; South West Scotland, 8·1 per cent. The only Area Boards to record decreases over the same periods were Merseyside and North Wales, 2·1 per cent, and North Western, 1 per cent. Taking the cumulative totals for the first six months of the financial year, 1952/3, compared with 1951/2, however, there are only two Area Boards with a substantial increase in sales—Southern, 5·4 per cent and South Wales 6·1 per cent; when the fourteen Area Boards are considered together the overall results for the periods show a drop of 0·4 per cent.

Corrugated Aluminium Sheathed Cable

One of the methods of sheathing cables with aluminium is to bend aluminium strip round the cable and to weld the longitudinal seam to form a loosely fitting tubular sheath. The internal diameter of the tube can then be reduced to that of the cable core by rolls which corrugate the sheath as described and illustrated below. The process was developed by the Pirelli General Cable Works, Ltd., and the research laboratories of the General Electric Company, Ltd.

THE manufacture of the Pirelli-General welded aluminium sheath is based on the production of a longitudinal butt-welded tube enclosing the cable core. An important precaution in this process, which is described below, is the need to space the welding heat zone away from the surface of the combustible cable core : to avoid damage to the core the sheath, as welded, is oversize and the internal diameter is then brought down to fit the core. Broadly, there are two ways of reducing the diameter—first, rolling down and, secondly, corrugation.

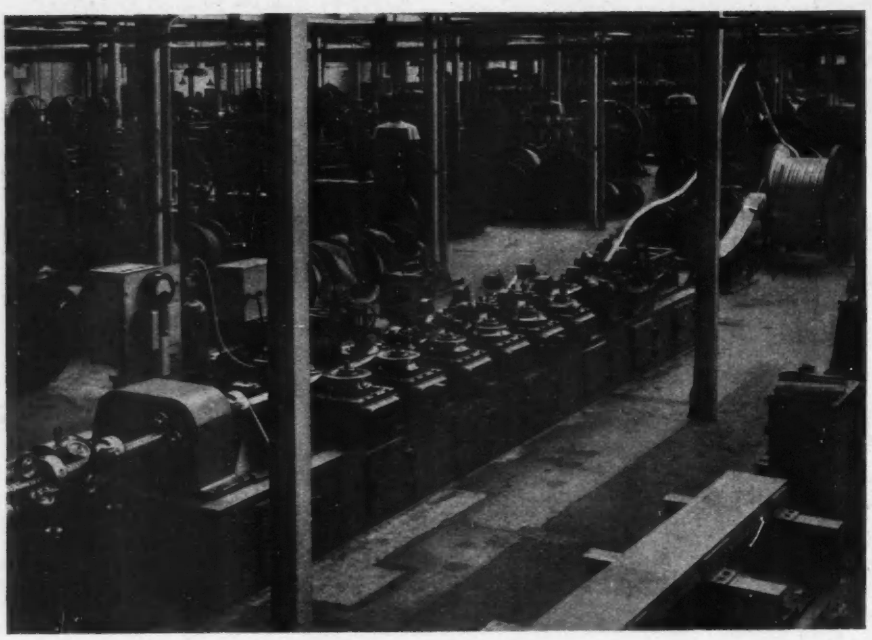


Fig. 1—Aluminium Sheathing Machine

In rolling down, the plain cylindrical sheath emerging from the welding head is reduced in diameter without alteration of form or appreciable increase in length, the surplus metal being absorbed in uniform thickening of the wall. In the second method the effective internal diameter of the slightly oversize welded sheath is reduced by a helical corrugation so that it just embraces the core. The resulting cable is very flexible in the sense that it requires little effort to bend it and that it withstands repeated bending on diameters appropriate to lead sheath cable without damage or undue distortion of the sheath. The bending performance, even with a much ligher gauge of metal than is usual for normal tubular sheaths, is such that this method is recommended by the maker for all cables except those in which the dielectric design would not permit an internally corrugated sheath.

An incidental advantage of the necessity to reduce the effective diameter after welding is that by variation of the depth of rolling down or corrugation, a single size of tube, as welded, provides for a range of cable core diameters, permitting an economic design of plant and accessories. The pitch, radius and range of depth of corrugations are graded in relation to the external diameter of the sheathed cable.

The Sheathing Process

Aluminium strip fed from a coil in a continuous length sufficient for the cable in hand is first passed through rotary shears which trim both edges, cutting the material to the exact width, and producing clean edges, which are essential for satisfactory welding. The external surface of the sheath is cleaned by high-speed rotary scratch brushes and the material is then passed to the first horizontal forming rolls.

The cable core is inserted at this point and the sheath progressively closed round it by five subsequent forming rolls, the last stage also acting as the seam closure roll for welding. Fig. 1 gives a general view of the machine.

The forming rolls are illustrated in Fig. 2. This design of horizontal rolls controls and forms the strip without damage to the butting edges, the surfaces of which have been prepared for welding at the previous stage, and immediately after welding the sheathed cable passes through horizontal positioning rolls and torsion check rolls, which correct any tendency for the sheath to rotate and so displace the weld seam in relation to the arc.

All the rolls except the last mentioned are driven through gears from a common shaft and provide the necessary motive power for the passage through the forming, welding and corrugating heads.

The formed and closed strip passes under the argon arc welding torch, which is mounted vertically above the closed sheath seam, and is attached to a compound slide which allows transverse movement for regulating the arc to the weld seam position and longitudinal movement for advancing the torch along the seam for restarting the weld (Fig. 3).

The G.E.C. twin-arc welding process was adopted because it was found to give optimum weld contour and to allow variation of width of weld to suit any particular conditions. This system of welding uses a twin-electrode argon arc welding torch fed from a three/two-phase Scott-connected transformer and draws balanced current from the supply. A high-frequency spark discharge unit is included which serves, to start the alternating current for welding. The use of this spark discharge allows the arc to be struck without the tungsten electrodes coming into contact with the work.

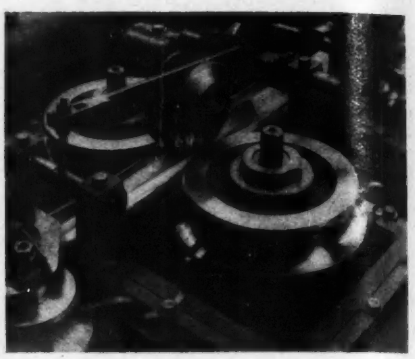


Fig. 2—Tube Forming Rolls

To avoid contact between the cable core and the bead of molten metal under the weld, which would damage the insulation and liberate gases harmful to the weld, several methods of protection were investigated.

The one finally adopted employs a shaped metal shoe as a backing strip interposed between the sheath and core, which may be water cooled, or may be used to supply inert gas to the underside of the weld.

Reduction of diameter by rolling down is achieved by passing the formed and welded tube through a planetary roll system incorporating four curved-tapered rolls of deep section driven at a fairly high speed. A useful range of cable diameters may be covered by a single size of tube as formed and welded.

The alternative method of diameter reduction by corrugation is put into effect by substituting for the set of four tapered rolls a radiused indenting roll and three thrust-opposing rolls

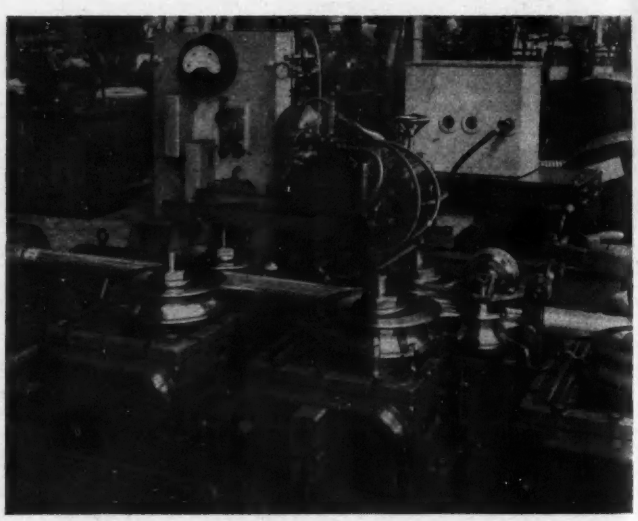


Fig. 3—Tube Closure Rolls and Welding Unit

(Fig. 4) driven at a predetermined speed in accordance with the pitch of corrugation required.

Although aluminium strip is available commercially in continuous lengths adequate for most of the normal types of underground cable, complete freedom from limitation of production length in manufacture, and the ability to join random lengths of strip are desirable. A technique of cross-joining strip by welding was

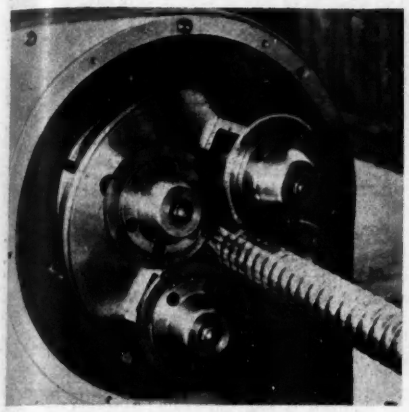


Fig. 4—The Corrugated Head

therefore developed along the same general lines as the welding of the longitudinal seam, except that single-phase a.c. is used with a single tungsten electrode, the arc traversing the butting edges of the strip ends, which are cut obliquely so that opposite end portions do not coincide when the joined strip is formed into tube.

The strength of the joint, which after peening is practically flush, is almost equal to that of the parent metal. The position of a joint is hardly distinguishable in a subsequently formed and welded tube.

Bending Tests

It is generally accepted that the bend test specified in British Standard No. 480 : 1942 (six bends on a drum of diameter 12*D*, *D* being

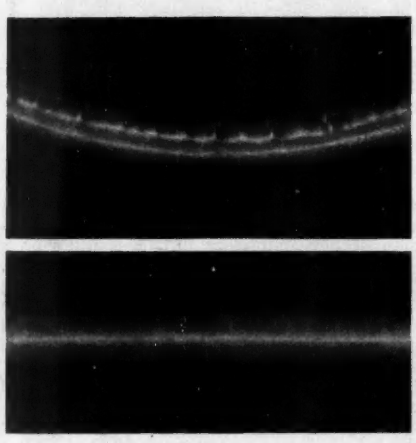


Fig. 5—Rolled-Down Sheath After Bend Test

the overall diameter of the cable) applied to a plain cylindrical aluminium sheathed cable produces sheath distortion such as might seriously injure the dielectric. Hence it has been agreed tentatively to increase the bend test diameter to 20*D* when testing such cables, and under these conditions the new welded cylindrical type of sheath manufactured by the rolling-down process has been found to behave satisfactorily. A tested sample subjected to three reverse bends at 20*D* is shown in Fig. 5 in the bent state and after restraightening.

In designing the corrugated sheath the aim has been to equal or surpass the performance of lead-sheathed cable in respect of ability to withstand repeated bends on the actual diameters laid down in British Standard No. 480 : 1942. The relevant clause in this Standard is primarily concerned with the behaviour of the insulation on bending of the cable and does not make any reference to the condition of the metal sheath after the test, but it has been recognised, in the course of this work, that mechanical distortion of a metal sheath so much harder than the traditional lead sheath might cause injury to the insulation under the severe test conditions specified.

Hence it was decided that, after the appropriate unmodified bend test, the aluminium must not only be free from cracks, but must show no excessive local distortion. The depth, radius and pitch of the corrugations are based on this requirement.

The condition of a 1·6in diameter cable before and after performance of the B.S. 480 bend test (six bends on a drum of diameter 12*D*) is shown in Fig. 6.

Weld Strength and Soundness

It is believed that the process described above can ensure standards of continuity and sound-

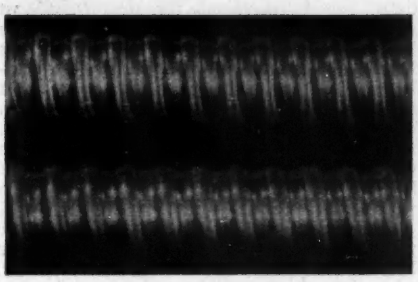


Fig. 6—Corrugated Sheath Before and After Test

ness in the weld comparable with those of an extruded sheath, and Fig. 7 shows the contour and microstructure of a weld in transverse cross section. The central fusion zone of the weld, on account of its greater thickness, is stronger than the parent metal and the portions adjacent to it are only slightly weaker than the remainder of the sheath wall. Hydraulic bursting tests at slow rates of strain may produce fracture at the weld boundary or at positions remote from the weld. Fig. 8 (upper) shows such a burst on a 2·7in diameter pipe of 0·098in wall thickness, which required about one minute under a pressure of 890 lb per square inch. At 800 lb per square inch a similar sample did not fail in 500 hours ; when the pressure was raised to 900 lb per square inch the burst was in the parent metal (lower photograph).

Hydraulic testing equipment has been designed

Fig. 7—Macrograph of Transverse Cross Section of Weld

and constructed at the G.E.C. research laboratories for the investigation of bursting characteristics over a wide range of test conditions, and we learn that the preliminary hydraulic tests on the corrugated sheath have shown that it has adequate strength to function satisfactorily in any of the accepted types of oil-filled or gas pressure cable without external metallic rein-

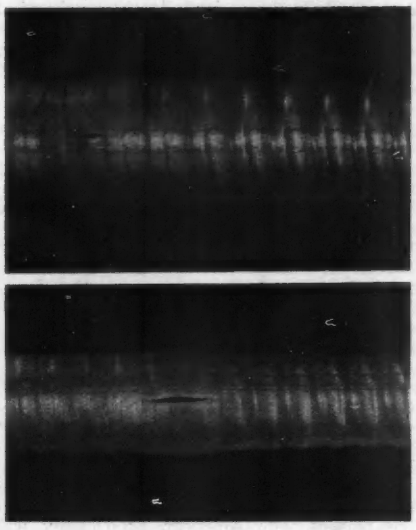


Fig. 8—Bursting Tests on Corrugated Cable Sheath

forcement. It is stated that the initial volumetric expansion associated with the corrugated construction is negligible at the maximum working pressures so far envisaged for such cables.

Field Installations

Argon arc welded aluminium-sheathed cable has been used in the important new distribution systems required for the recent extensions on the company's Wembley Estate, including over 1000 yards of 11kV ring main cable. Most of these cables were buried direct, but there were also some difficult duct runs which were successfully negotiated, the work being greatly facilitated by the flexibility and lightness of the cables, all of which had corrugated sheaths. Jointing presented no difficulty to men with normal experience in the handling of lead-covered cables. No special training was given apart from a demonstration of the "tinning" of the surface of aluminium with a proprietary tin-zinc alloy as a preliminary to plumbing with ordinary wiping solder.

Books of Reference

Colliery Year Book and Coal Trades Directory, 1952. London : The Louis Cassier Company, Ltd., Dorset House, Stamford Street, S.E.1. Price 30s.—The thirtieth edition of this year book contains, like its predecessors, a great deal of useful information about the British coalmining industry and its allied trades. It includes lists of Ministry of Fuel and Power officials and departments, of officials and establishments which are under the direction of the National Coal Board, and a list of all the coal mines in this country, together with the names of their managers, the numbers of their employees, and their output figures. There is also a "mines index," which gives the names of the owners of various mines prior to the nationalisation of the industry. Other lists in the directory section of the book contain the names of coal merchants and exporters and particulars of their various trade organisations. The statistical section of the book is especially comprehensive, as it covers not only the British coalmining industry, but also output, consumption and trade figures relating to foreign coal producing countries. Other chapters of the book contain the text of the Coal Industry Nationalisation Act, 1946, and the Coal Industry Act, 1949, Mines Regulations, and a review of the coal industry's activities in 1951—all of which users of the book will undoubtedly be glad to have so readily accessible.

Productivity in Steelmaking

THE recommendations made in the recent report of the iron and steel productivity team are to be discussed in detail at a series of technical conferences organised by the British Iron and Steel Research Association, the Iron and Steel Institute and local metallurgical societies. The first of these conferences has been organised by the British Iron and Steel Research Association, and was held at the beginning of this month at Ashorne Hill, Leamington Spa. It was attended by 114 delegates from thirty-five steelmaking companies which represent over 90 per cent of this country's open-hearth steelmaking capacity. The discussions were opened by three members of the productivity team. They were Sir Charles Goodeve, the leader of the team, who spoke on "The Size of British Steel Works: Recommendations for the Future"; Dr. D. F. Marshall, of Park Gate Iron and Steel Company, Ltd., who dealt with "Open-Hearth Productivity and Fuel Consumption"; and Mr. D. Kilby, of Colvilles, Ltd., who spoke on "Open-Hearth Practice in America: Possible Applications to British Practice."

At the opening of the conference Sir Charles Goodeve said that it was necessary to see whether it might be possible from the facts given in the report to specify the optimum size of open-hearth furnaces. Several factors entered into this. Fuel, refractory and man-hours consumption rates all favoured large furnaces. One of the reasons why American productivity was greater, was that each time a workman there pushed his control levers or tapped a furnace a larger amount of material was moved. That, combined with lighter manning and the traditional higher driving rate accounted for a very large part of the difference in productivity. It was true that large furnaces were more costly to build than small furnaces but accurate figures on this point were difficult to obtain. *Pro rata* the consumption of constructional materials should actually be less. The productivity team had finally concluded that it was possible to recommend that all new basic open-hearth furnaces in this country should, as far as possible, not be smaller than those shown in the following table:

Recommended Sizes of Basic Open-Hearth Furnaces

	Normal tons tapped	Furnace week productivity to be expected, tons
Cold metal	150	... 2000
Hot metal:		
Fixed (for low or moderate phosphorus)	200 to 250	... 3000
Tilting (for high phosphorus)	300 to 400	... 3000

It was also possible to lay down the minimum number of furnaces desirable in a melting shop to give an even flow of steel to the rolling mills. In the United Kingdom, the minimum number was probably six furnaces, except where large tilting furnaces were used when three or four might be appropriate.

The conclusion reached by the team was that the minimum size of an integrated works in the United Kingdom should be that which would give an output of 750,000 to 1,000,000 tons of steel a year. Sir Charles thought that that was not going too far, as in the U.S.A. there were primary mills with a throughput of 2,200,000 tons a year.

In the subsequent discussion, most speakers accepted that the minimum figure of six open-hearth furnaces to service a rolling mill was justified and was a recommendation that had generally been put into effect already. Fewer furnaces, larger in relation to mill capacity, giving relatively large "gulps" of metal needed a cushion of soaking pits, whereas a larger number of small furnaces giving more frequent and relatively small "gulps" could often almost do without soaking pits altogether. It was also suggested that six furnaces was not only the minimum but also somewhere near the maximum number of furnaces for economic operation in one shop, if interference between different units and unwieldy multiplication of charging and shunting capacities were to be avoided. At the other end of the scale, it was pointed out that blast furnace capacity should, in general, exceed open-hearth demand by a sufficient margin.

In the discussion on how far the productivity gap between American and British furnaces was a real one which could be lessened, comment turned on the lighter metallurgical load carried by American furnaces. It was pointed out that with copious supplies of consistently low phosphorus iron, and high-grade oil or natural gas for fuel, American furnaces carried a far lighter slag than British furnaces. Where 20 per cent and even 30 per cent of slag was commonplace in Great Britain, 10 per cent and 15 per cent of slag was seldom exceeded in the U.S.A., with all the advantages this meant in heat transfer to the steel bath and in refining time. Some speakers maintained that the difference to productivity from this factor might be as much as 25 per cent to 35 per cent, and that if British steelmakers could have consistent supplies of iron of even 1 per cent to 1·2 per cent phosphorus, productivity would be raised considerably. Most speakers, however, thought that the difference in productivity attributable to raw materials supplies was more likely to be in the neighbourhood of 10 per cent. Consideration of what British steelmakers might do under American conditions was rightly felt to be unrealistic. Discussion centred on what could be done to get the greatest advantage from the adoption of larger units, and what measures could be taken to increase productivity from existing units.

One speaker suggested that the basic Bessemer process itself might be more economic than the large open-hearth furnaces either fixed or tilting, where iron quality was beyond a critical value, in spite of the larger iron losses inherent in the process. The so-called turbo-hearth process and its offshoots with oxygen enriched blast could decrease that disadvantage.

The conference generally agreed that there was much room for improvement in the design of melting shops to obtain quick charging rates; in fact, it was suggested that more improvement could be gained here than from the design of furnaces. One speaker gave as an example his own shop where overhaul of charging facilities, which had been severely strained during the war, had increased productivity by 30 per cent. It was remarked during the discussion that in this country better scrap preparation could be demanded both from scrap merchants and from steel works mills, where there was often room for better sorting at the finishing end. If care was taken in packing a uniform proportion of light to heavy scrap, it was more possible to standardise pan and bogey weights. While our charging boxes could not be made as large as those used in the very large furnaces in the U.S.A., those in use could sometimes be improved, especially by building larger doors into the furnaces, by the use of archless doors, or by other means.

On the subject of fuel consumption, it was thought that the American practice of using double burners in open-hearth furnaces offered possibilities in Great Britain. Another common practice in the U.S.A. was that of increasing the number of jets in a burner tube or using two or more tubes in one burner accurately. One furnace had been seen in which four alternative fuels could be changed over quickly and easily. It was stated that where charging facilities were good, the devices which split up the fuel stream appeared to give an increased productivity of about 5 per cent. The role which flame radiation research would play in securing the best value from fuel was also discussed. It was pointed out that some of the results obtained from the international project at Ijmuiden had already been used in work on burner design, and work showing the best steam pressures for oil atomisation was also proving successful.

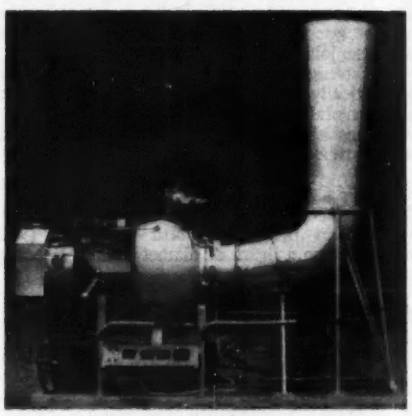
Other matters covered in the discussions at the conference included refractories, the human elements, and the rate at which furnaces in this country are driven, compared with the U.S.A. On this last point, it was stated that the British Iron and Steel Research Association had been working for some time on the use of available statistics for comparing driving rates and outputs in different works. A report which has now been issued to all steelmaking members of B.I.S.R.A. gives the productivity and driving rate figures of all furnaces in this country for 1951, compared with figures for 1950 given in the productivity team's report. Firms are "coded" and each firm knows its position in this anonymous league table and can act accordingly. It is intended to issue such information annually. It is of interest to note that if driving rate is plotted against size of furnace, there is no correlation whatever. There is also a wide scatter within the categories of furnace so that differences cannot all be explained by raw material qualities and other uncontrollable factors. Indeed, some of the highest driving rates, it has been discovered, come from some of the oldest plants.

Small Gas Turbines

OUR illustration shows a gas turbo-air compressor completely assembled on its transportable rig. It is one of the range of "Turbomeca" gas-turbines, which develop horsepowers extending from 160 to 400 h.p., and are designed for applications requiring either propulsive thrust or shaft drive.

The "Turbomeca" gas-turbines have been developed in France under the direction of Monsieur J. Szydlowski, and a great deal of development has been completed over the past fourteen years.

The basic design concept of a single-stage centrifugal compressor, a compact annular combustion chamber of high efficiency, and



A "Palouste" Air Compressor

single or multi-stage turbines is retained in all the engines. The shaft drive is either an extension of the compressor turbine shafting or is separate from it and driven by a free turbine. The annular combustion chamber, with rotating disc fuel distributor and burner, is a notable development which allows the engine to be extremely compact—an important advantage in many applications.

The three main groups of engines consist of shaft drive, jet and air compressor designs.

The shaft drive units range from 158 h.p. to 400 h.p., and include a free turbine unit of 275 h.p. The applications of the shaft drive units include the driving of industrial or aviation auxiliary equipment. The jet engine designs vary in thrust from 220 lb to 880 lb and include a ducted fan engine of 795 lb thrust. They are principally for aviation, for such projects as target aircraft, guided missiles, auxiliary booster units, light aircraft and military jet trainers and for small-scale research aircraft. The air compressors in which the air is supplied by an oversize main compressor, are units capable of delivering from 1072 cubic foot to 1815 cubic foot per minute at a pressure of 41·2 lb per square inch. There is also a shaft-driven independent compressor, giving 2180 cubic foot per minute at a pressure of 31·6 lb per square inch.

This range of gas-turbines is now to be manufactured in this country by the Blackburn and

General Aircraft, Ltd., Blackburn-Torbomeca Division, 43, Berkeley Square, London, W.1, who have acquired the manufacturing and selling rights in the United Kingdom and in certain parts of the Commonwealth.

Diesel Mechanical Shunting Locomotives

We reproduce below a photograph of one of two new 0–4–0 diesel mechanical shunting locomotives which have been built by Robert Stephenson and Hawthorns, Ltd., of Firth Bank Works, Newcastle upon Tyne, for special service requirements in the steel works of Thos. Firth and John Brown, Ltd. The general layout of the new locomotives is very similar to that of the 300/330 h.p. Stephenson-Crossley locomotives with 0–6–0 wheel arrangement supplied to the British Electricity Authority and exhibited at the Festival of Britain South Bank Exhibition in 1951. The engine is of the Crossley four-cylinder, two-cycle, loop scavenge design and it has a one-hour traction rating of 220 b.h.p. at 750 r.p.m. The cylinder bore is 7in and the stroke 9in.

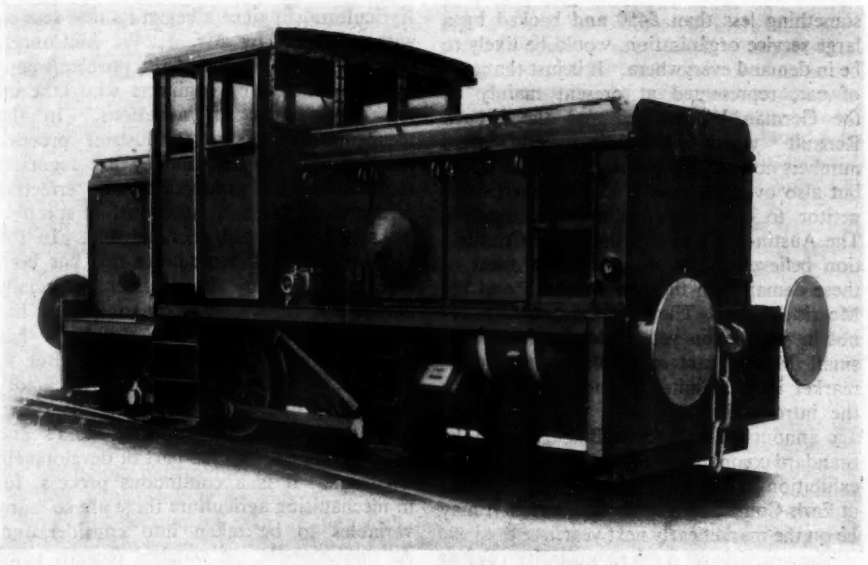
Each locomotive weighs 30 tons in full working order and with a wheelbase of 6ft is designed to work over minimum curves of 47ft. Drive is transmitted from the engine through a Vulcan-Sinclair hydraulic coupling and a Bostock and Bramley three-speed gearbox to a jackshaft. In first gear the locomotive has a speed of 3·82 m.p.h. and a tractive effort of 17,250 lb; in second gear a speed of 6·71 m.p.h. and a tractive effort of 9850 lb; and in third gear a speed of 11 m.p.h. and a tractive effort of 5950 lb. The haulage capacity varies from 1407 tons to 465 tons on the level.

One handwheel fitted in the locomotive cab controls starting, stopping and reversing of the engine and the only other engine control is that for controlling the speed from idling at about 300 r.p.m. up to the full speed of 750 r.p.m. Compressed air starting arrangements are provided and an ample and constant supply of compressed air is available from three air compressors which are neatly arranged at the end of the engine.

Both hand and Westinghouse air brakes are fitted, air being provided from the engine starting system through a reducing valve. Serck sectional cooling elements for water and lubricating oil are bolted to headers built in with the body casing, and the fan is driven from the engine.

The cab is totally enclosed and, as will be seen from the photograph reproduced, the driver has an unobstructed view in all directions. Drop windows are provided at the sides and the fixed end windows are fitted with wind-screen wipers. The locomotive is equipped with C.A.V. electric lighting equipment, which gives adequate illumination of the cab interior and the various instruments.

The builders state that in designing these locomotives, special attention has been given to accessibility, and should any part require attention, access can be had to it with the minimum of trouble.



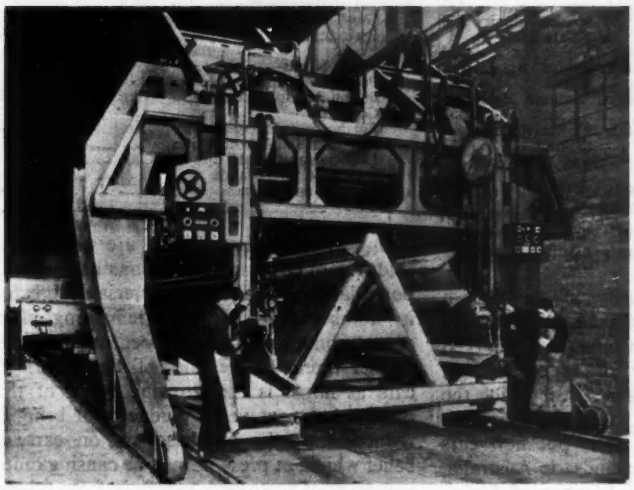
220 b.h.p. Diesel Shunting Locomotive

Large Automatic Arc Welding Machine

A large portal frame design of automatic arc welding machine, which has been designed and built by Fusarc, Ltd., of Team Valley, Newcastle upon Tyne, for Alexander Findlay and Co., Ltd., of Motherwell, is illustrated on this page. This machine has been specially designed for welding prefabricated H and box-section girders up to 100ft long and, with the use of suitable fixtures or manipulators, it can be adapted for a variety of other work. It consists essentially of a rigid portal frame structure carrying two Fusarc automatic welding heads, and which is supported on bogies running on rails let into the shop floor.

The two welding heads are arranged to run on an adjustable runway arranged transversely across the width of the main structure and supported by a counterbalanced boom. Each welding head is operated independently through a separate control box and is supported on a vertical slide through which its height can be adjusted. The carriages to which the welding head slides are fitted can be traversed by hand across the full width of the runway, and a motorised traverse gear, giving welding speeds from 7in to 28in per minute, can be used if required. The width between the support members is 17ft, whilst the actual welding traverse is 14ft.

Height setting of the cross traverse runway is effected through motors controlled from the operator's panel, and this movement in conjunction with that of the head slides allows for an operating height between 1ft and 11ft. Longitudinal traverse of the main structure along the rails is motorised to give a high-speed setting rate of 16ft per minute and an infinitely variable range of welding speeds between 7in and 28in per minute. At present the length of track laid down for the installation is 100ft, and the installation is designed to carry out any straight-line or rectangular work within the limits of the 100ft by 14ft floor space in which it is now operating. By extending the supporting rails and by the addition of roller bases or tilting turntables, the range of work could be increased.



Automatic Arc Welding Machine in Operation

In the illustration we reproduce, the machine is shown welding a 60ft girder fabricated from two sections, comprising two ⅜in plates, 14½in and 12½in in width, fillet welded together, and the web which is 5ft by ⅜in section. All welding is carried out at 580A, and in this job the ⅜in fillets are welded at 12in per minute and the ¼in web fillets at 14in per minute.

Introduction of New Weather Minima Regulations

Arrangements have now been made to introduce an amendment to Article 17 of the Air Navigation Order, 1949, which will give effect to the recommendations made by Lord Brabazon in his report on the landing of aircraft in bad weather, and by Sir Walter Monckton in his report of the inquiry into the Viking accident which occurred at London Airport in October, 1950.

The new provisions are based on the concept of reporting runway visibility in terms of runway visual range. This is the distance along the runway which a pilot approaching to land or taking-off would be able to see the runway's lights or runway markers. The use of cloud base as a limiting factor in expressing weather minima will be replaced by critical height; this height being the minimum height above aerodrome level to which an approach to landing can be safely continued without visual reference to the ground.

At certain aerodromes in the United Kingdom, runway visual range will be measured by the aerodrome authority and communicated to the pilot. Under the new regulations, if the runway visual range so measured is less than his company's minimum, the pilot will be forbidden to take-off or to make an approach to landing. Operators of public transport aircraft registered in the United Kingdom to which this regulation applies will continue, as before, to be responsible for laying down the weather minima for their own aircraft. Details of such weather minima will have to be notified to the Ministry of Civil Aviation.

It is expected that the new regulations will be effective as from Monday, November 10, 1952.

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THE BRITISH MOTOR CAR INDUSTRY

Although the popularity of the British car is now a fully established asset abroad, the last two years have seen a marked decline in the number of export orders, because of a variety of causes over which the industry has no control. In Canada, restrictions on hire purchase have put new cars out of reach of many thousands. In Australia, for similar reasons and because of higher sales tax, the order books have been sadly depleted. On the European continent, the export of cars to Switzerland, Belgium and Holland has been hit by competition from Western Germany, France and Italy, countries which between them are now producing at the rate of about 800,000 cars a year, a third of which are available for export. In consequence, and because of the general shortage of raw material caused by the demands of the rearmament programme, in particular sheet steel, the export figures in 1951 dropped 30,000 below the 1950 figure of 369,000, and to judge from the results available for the first eight months of this year, a further drop of about 6 per cent is likely to occur in the current year. These figures are by no means alarming. The value of exports last year reached £248 million. But it would be wrong to assume too confidently that the drop is only temporary. Continental competition is definitely growing, in particular that from Germany, and a steel shortage, which affects expansion of production in this country, is felt less severely over there, as Germany's contribution to the European rearmament programme is still comparatively small and likely to remain so.

In these circumstances the British motor industry, which for the last five years has to a large extent adjusted its production to export requirements, might well be allowed to pay more attention to the needs of the home market. Not all existing models have proved as attractive at home as abroad. For instance, it has proved less easy to sell certain cars to customers at home than agents expected, simply because by British standards those cars are expensive both to buy and to run. Nearly half the models available in Britain to-day, i.e. practically all the cars selling at more than £1000, are now being sold free of covenant restrictions because the potential buyers are not appreciably greater in number than the cars remaining after export commitments have been satisfied. A further threat to the sales of higher priced cars at home is the growing belief of the public that next year's budget will bring a reduction of the purchase tax on cars, a belief which, at present, may be causing quite a number of customers to refrain from taking delivery of previously ordered cars. There has also been a slump in the market value of many second-hand models, and it is interesting to note that the value of big models has dropped proportionately far more than that of smaller cars. The decline in the number of people who can afford to buy a big car or meet the high cost of running one is by no means restricted to this country. It applies equally to other countries, especially those on the Continent. The fear is, therefore, reasonable that the motor industry will find many markets greatly restricted, unless means are found to produce cars within the purchasing power of the average wage earner. A small compact four-seater of light weight and simple design, priced at something less than £450 and backed by a large service organisation, would be likely to be in demand everywhere. It is just that type of car, represented at present mainly by the German Volkswagen and the French Renault which sells in very great numbers not only in their respective countries, but also overseas, and is the strongest competitor to our own medium-sized models. The Austin-Nuffield British Motor Corporation believes it has the answer to most of these demands in the new Austin 7 and the Morris Minor. The first car, however, is not in production yet, while the number of small Morris cars available to the home market is still limited. Another small car, the introduction of which was some time ago announced by Sir John Black, head of the Standard company, is not ready. It is not on exhibition at the Motor Show which opened at Earls Court last Wednesday, though it may be on the market early next year.

The scarcity of modern austerity cars at the Motor Show, however, should not detract attention from the fact that in every other respect the British motor industry has made great efforts to improve the general acceptability and performance of its models. Several entirely new designs of car are at the Show. There are, it is true, no startling changes or novel constructions, but, as far as a preliminary survey indicates, all these newly exhibited cars are very well made and likely to attract new customers. Before the war potential buyers went to the Show with the idea of witnessing at least some "revolutionary" developments. But nowadays we appear to have reached a stage of evolution where the general specification of motor cars remains, year by year, much more uniform and stable than in pre-war years. Then very few individual models were produced at a rate greater than 25,000 vehicles per year and manufacturers were thus able to make quite major alterations at intervals of about a year. But now the expenditure for developing a new car and for tooling-up for large-scale production has become so great that the basic design has to remain more or less static for several years if the car is to be sold at an economic price. In these circumstances, it might be thought that the scope for creative designers of original talent is limited. Perhaps it is. Yet all the big motor manufacturers have found it advisable to form groups of talented engineers and designers to work upon long-range designs of a speculative nature. Such a policy should secure that there is no slackening in the pace of technical development. Certainly there are a number of potential improvements which have not yet been explored in this country and might well repay exploration. To name only a few, there are the use of diesel engines in motor cars, the development of air-cooled and two-stroke engines, and the use of simple semi-automatic transmissions. International competition, particularly from the Continent, should prove an incentive. Totally new and promising lines of approach to the solution of several problems which are still waiting to take practical shape may soon be opened up.

THE DEVELOPMENT OF AGRICULTURAL ENGINEERING

Last week, the Institution of British Agricultural Engineers began its new session with a paper, by Mr. F. W. McConnel, which dealt with some of the problems continually confronting engineers who take up the development of inventions. In the mechanisation of any industrial process, much time, skill and money are regularly required for the production and perfecting of machines that will perform their specified tasks efficiently and economically. In the mechanisation of agriculture this has been revealed on many an occasion, especially in the last twenty years or so. There has been no lack of inventive skill; it has inspired ideas that are excellent. But to translate those ideas into satisfactory working propositions has entailed a tremendous amount of "dotting the i's and crossing the t's" on the part of development engineers. It is a continuous process, for in mechanising agriculture there are so many variables to be taken into consideration. As one example, we watched recently some competitive trials of machines for the com-

plete harvesting of potatoes. In the last few years, the design and efficiency of machines of this nature have been rapidly advanced, but, nevertheless, damage to a portion of the harvested crop and failure to sort out completely the stones from the potatoes have not yet been entirely eliminated !

In the course of his paper, Mr. McConnel mentioned three things in particular which farmers require from engineers. They are that the machines at present on the market should be improved, both in life and performance ; that all machinery should be simplified and cheapened ; and that machines should be provided to do any job better or more economically than is possible with existing equipment. Certainly, in making these points, Mr. McConnel was reiterating what has been said before—in these columns among other places—but they are statements that bear repetition. The progress of agricultural mechanisation has undoubtedly led to greater productivity in the farming industry ; more work is being accomplished with less manual effort on the part of farm labour. But Mr. McConnel thinks there has now been reached " a time when far more thought should be given to new kinds of machines before farming methods are anchored solid by the preponderance of their own machinery." At the same time, he feels that, since the beginning of the second world war, farmers have been fed on new machines or new productions at a high rate and that " these haven't been digested." On the surface, these two statements may seem to contradict each other. Yet from them we think it may be reasonably deduced that the design and development of agricultural machinery by engineers have been more rapid than the growth of the farmers' experience in the use of it. The majority of farmers would never claim that they were engineers, but seldom in these days are they unwilling to give careful consideration to the possibilities of further mechanical assistance which may be put to them. To this problem, a solution is to be found—and, indeed, is being found—by increasing co-operation between farmers and engineers. The work of engineers cannot end with the design, development and production of agricultural machinery ; it must at all times include a readiness to assist farmers and their staffs to become experienced in the handling of that machinery.

To that end, the Institution of British Agricultural Engineers is already at work. It is encouraging and assisting the organisation of part-time courses for farm machinery operatives, designed to provide suitable theoretical and practical training. This is only one of the Institution's educational activities. Its association with the establishment of the M.Sc. degree in agricultural engineering at Durham University, and its inauguration more recently of a National Diploma in Agricultural Engineering are services which cannot fail to be of great benefit to the future of mechanised agriculture. Agricultural engineering—looked upon by some perhaps as a new technology harassed by teething troubles—is now rightly taking an important place in which the services of men of high technical ability are essential. The fruits of the research and development work performed by such organisations as the National Institute of Agricultural Engineering and by many tractor and machinery makers, are regularly proving their worth in the agricultural machinery industry. But, as in every other section of our profession, there is always some fresh aspect of agricultural engineering to be studied, some new problem for which the best possible solution is necessary. Mr. McConnel's paper indicated some of the problems in so far as they relate to the present and future development of agricultural machinery. The Institution of British Agricultural Engineers, though still one of the younger institutions, is seeking to provide every possible opportunity for the full exchange of views, for the spread of technical knowledge, and for the continuing improvement of agricultural engineering education. Its work along these lines will, we are confident, command the support and encouragement of engineers.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

A GAS-TURBINE LOCOMOTIVE EXPERIENCE

SIR,—Because popular interest in the steam locomotive is largely emotional, it is inevitable that some of what is written about it does not exactly line up with reason and that individual opinions of the same feature in construction or operation may differ widely. The objects and procedure of those who ride on footplates also show variations to the extent that one observer may have difficulty in understanding the viewpoint of another. Published accounts of rides on locomotives are inevitably tinged with respect for the desires of the Railway Executive ; the most interesting things that happen on locomotives will never be published at all, and in fact are unlikely to be observed by anyone but drivers, firemen and acquaintances travelling in what have been called " black market " conditions.

In writing any account of a journey on a locomotive there is an inevitable tendency to make comments or comparisons and to offer opinions, but a writer who feels an urge in any of these directions should remember first that (like all others) instruments on locomotives have inherent errors, secondly that the basic principles of the development of power in steam locomotives have long been well understood, and thirdly, that a wealth of information exists about the times achieved by most classes of express passenger locomotives in hauling British trains. Familiarity with the whole background may make it possible to question narrowly-based opinions that are not supported by broad facts or, on the other hand, to make deductions not obvious from consideration of details of one run alone.

Mr. E. H. Livesay, who has written often and entertainingly of locomotive footplate experiences, specifically abjures the recording of any but a very few figures and sees little object in timing trains in the extent of detail that has become traditional. Mr. O. S. Nock has made many footplate trips and commonly takes as many notes as possible in circumstances that are never easy and often difficult. Mr. C. J. Allen concentrates on train timing and, with the assistance of many collaborators, has published thousands of detailed " logs " of the running of British trains. The writer's enthusiasm for these pursuits has faded with the passing of novelty, but he is glad that there are others willing and able to make records from which it is possible to extract significant figures on locomotive performance. Mr. Livesay thinks that some of these records are excessively detailed, but that does not detract from any value they may have.

In THE ENGINEER for October 10, 1952, Mr. Livesay records that a gas-turbine locomotive with a load of 445 tons approached Box Tunnel at 52 m.p.h., and emerged from the eastern mouth at 44 m.p.h. Certain Western Region locomotive men, observing this, gave it as an opinion that no " King " class engine could have done the same thing. Mr. Livesay comments in a way that suggests an inclination to accept this opinion regardless of what evidence may be brought to the contrary. It would seem, however, that such an attitude (whether it is in fact that of Mr. Livesay or not), is hardly defensible. If records show that on one or more occasions a " King " did surpass that particular performance, then the opinion is discredited. Even if no record can be found to that effect, the opinion remains as no more than an opinion. Furthermore, it is surely permissible to apply rational analysis to known performances and to conclude that if a " King " has shown ability to develop as much power as would suffice to equal the particular effort of the gas-turbine locomotive, then again the performance is possible by a " King " and so the opinion is discredited. It is not prudent to declare any performance to be beyond the capability of any class of locomotive unless it demands a power output greatly in excess of any that is known to have been developed by any locomotive of comparable dimensions, and even then it is not safe. Now the figures quoted by Mr. Livesay for the gas-turbine locomotive's run through Box Tunnel correspond to a mean drawbar horsepower of about 1600 for 3 or 4 minutes, or, if the speedometer was reading 4 m.p.h. " low," perhaps 1750 d.h.p. Certain published timings of locomotives of the " King " class correspond to the development of about 1700 d.h.p. for a few minutes. In face of this, the statement that no " King " could duplicate this feat of the gas-turbine locomotive is unjustifiable. It may be that no " King " has ever run through the Box Tunnel with 445 tons in the time made by the gas-turbine locomotive on this occasion, but no one can be certain of the fact and it would be rash to opine that something is impossible just because the opiner has never seen it done. Mr. Livesay's readiness to champion the opinion of his companions against all factual comers does credit to the regard in which he holds them, but in principle it conflicts with reason and on the particular facts of this case it fails with a lost cause.

From the passing time and the speed of a train at each of a number of strategic points on a journey it is possible to estimate the mean drawbar horsepower over each of the intervening stages (see THE ENGINEER, October 12, 1951), by using a train resistance formula such as that of Johansen. The estimation of internal power loss in the mechanism of a locomotive involves appreciably greater uncertainty than in the case of coaching stock. If the steam conditions at the steam chests, the cut-off and the effect of leakages in valves and pistons were known, it would be possible to calculate the indicated horsepower and this, less the power lost in the engine and tender, is the power available at the rear of the tender. The second method of reaching the result is useless in practice as the average cut-off for the ends of the cylinders of a locomotive is not determinable with any satisfactory accuracy from the normal equipment of a locomotive.

Cut-off indicators in general are quite unreliable and less useful in estimating cut-off than is the process of determining the ideal indicator diagram that would correspond to the indicated horsepower required to move engine and train at the observed speed. There is, in fact, little object in recording the indicated cut-off except that, by comparison with calculated cut-off it affords a measure of the error in the cut-off indicator. Most enginemen are aware that the cut-off indicator reading does not mean much and work

by the "feel" of the engine and the sound of the exhaust. Others try to obtain an idea of the extent of the error on a particular engine by noting the cut-off reading when the engine is stationary and the valve mechanism in mid-gear. Still others, no doubt, follow the natural instinct to assume that a pointer-reading is right (how many people pause to question the time indicated by a public clock ?), and the results are occasionally interesting. One such instance was noted by Mr. Nock in THE ENGINEER, July 25, 1952, page 116, and the circumstances repay examination.

A Gresley "Pacific," No. 4482, of Class "A. 4," had brought a heavy train from Peterborough to York and continued thence to Newcastle after a change of crew. The first driver reported that the engine was steaming badly. This appeared to be confirmed by the fact that after a fast start from York with boiler pressure initially at 250 lb per square inch, there was a rather rapid drop to 180 lb per square inch, and later to 135 lb per square inch, despite which the engine hauled the 610 tons from Alne to Croft Spa, a distance of 30·3 miles with a net rise of about 64ft at an average speed of 59 m.p.h., and an average boiler pressure of about 145 lb per square inch. This involved a drawbar horsepower of about 1200 as part of an effort sustained over several hours and this represented good going for an "A. 4," even with the full rated boiler pressure of 250 lb per square inch. It is worthy of note that the engine was able to produce a creditable power output (more than any timetable demands to-day) with boiler pressure 40 per cent below the normal figure, but when we read that the cut-off was shown as 12 per cent, which is lower than is commonly used in these engines with full boiler pressure, we ask the obvious question "How low might the cut-off have been to do the same work with 250 lb in the boiler ?" In other words, 12 per cent cut-off is improbably low, and Mr. Nock remarked that the power developed suggested a rather higher figure.

But we can go further than this. To the 1200 d.h.p. for the train we add a proportionate amount (320 h.p.) for the resistance of the 164 tons of engine and tender as a vehicle and a further 180 h.p. which is an estimate for the machinery friction in the engine. The total of about 1700 h.p. at 59 m.p.h. means a mean effective pressure of 65 lb per square inch in the cylinders and the average steam-chest pressure was not higher than 145 lb per square inch. By trying a few "ideal" indicator diagrams, with no throttling at cut-off, no loss by exhaust before the end of the stroke and compression from (say) 10 lb per square inch at the point corresponding to the assumed cut-off, it is found that a cut-off not earlier than 33 per cent is necessary for an M.E.P. of 65 lb per square inch. The effects of throttling and early release have been investigated and the results generalised (see THE ENGINEER, February 10, 1950), and from these the necessary cut-off is estimated to be about 42 per cent, which does not disagree with the lower limit calculated for impossibly idealised conditions. We may therefore accept a figure of 40 per cent as being about right, and conclude that the cut-off indicator was very badly in error and showed a figure much lower than the true one.

Now assuming that the driver did not realise the extent of the error (and there is no reported suggestion that he did) and even if the engine were steaming perfectly, what would be the effect of the error in starting northwards from York with full boiler pressure ? After once attaining the speed at which slipping ceased to be an imminent possibility the cut-off would be much later than usual, the acceleration in its early stages would be higher than usual, but as speed rose above about 40 m.p.h., the boiler would tend to be overtaxed and pressure would drop. This, according to the report, was exactly what did happen. The first 2 or 3 miles were covered in quick time for an "A. 4" with a load of 610 tons, the boiler pressure tended to drop soon after the start and as speed rose the pressure fell more quickly before finally settling down to about 145 lb per square inch. There is thus no need to postulate "bad steaming" to explain the observed sequence of events. On any engine on a level road, the cut-off may be set as late as the driver pleases, and the engine will continue to run but the boiler pressure will drop to the point at which the supply from the boiler equals the volume-demand of the cylinders. It is reasonable to suggest, therefore, that the driver in this case had inadvertently run the engine "out of breath," and it seems possible that his predecessor's report of "She won't steam" had been based on the results of similar action south of York.

Mr. Nock has recorded in another place that, north of Darlington on this run, boiler pressure came gradually up to 225 lb per square inch, which also suggests that the engine may not really have been steaming so very badly after all. It was not stated whether the gain in pressure was achieved by reducing the regulator opening or by bringing cut-off earlier than the incredible 12 per cent. It seems likely that, on account of its negative error of about 25 per cent this cut-off indicator could have been set to a backward gear indication with the engine still pulling effectually forward. Such a condition is never specified in any formal record but its occurrence has often been reported without, however, making much impression upon those who firmly believe that cut-off indicators necessarily indicate cut-off.

The remark, "She won't steam" means that full boiler pressure cannot be maintained in running conditions that usually permit it. It is hardly applicable just because low boiler pressure results from "thrashing" either deliberate or inadvertent. The power output by No. 4482 on this run was comparable with that of good performances by "A. 4s" with full boiler pressure, and if the engine was indeed "not steaming," the effect on power output was not noticeable.

Reports of footplate trips are always interesting, but writers should make sure that no opinion expressed is in conflict with the facts of the particular run and their implications or with the background of information that exists about the internal and external details of locomotive performance. If the main object of an account of a trip is to convey the writer's impressions of it, then it is safer to omit figures altogether. If, on the other hand, the aim is to present facts and figures, then comment is better avoided, dull though the resulting report may appear. The type of report most difficult to write, without risk of inconsistency, is the one that attempts to combine enthusiasm for the engine and its crew, consideration for the preference of the Railway Executive, figures taken from unreliable indicators, and deductions made without due recognition of possible sources of error and misunderstanding. Both enthusiasm for locomotives and figures about performance have worthy exponents, who may well respect each other, but a mixture of enthusiasm and figures needs composing with care and dispensing with discretion.

W. A. TUPLIN

Sheffield, October 14th.

HISTORIC RAILWAY COACHES

SIR,—May I trespass on your columns to suggest that the Railway Executive preserve in perpetuity the two coaches reconditioned for exhibition during the King's Cross Centenary Exhibition ?

Both are of historic interest. The East Coast Joint Stock vehicle is a typical Howlden coach of the end of the nineteenth century, with its clerestory roof and the then newly-introduced Pullman vestibule and Buckeye coupler.

The other coach, G.N.R. No. 3034, was one of the first restaurant cars built by the young Mr. Nigel Gresley during the year after he succeeded Mr. E. F. Howlden at the Doncaster carriage shops. It was contemporaneous with his famous "Manchester bogies," in which the now standard elliptical roof was introduced to Great Northern main line train sets.

The six-wheeled carriage bogies are gradually disappearing and make another argument for preservation of this coach.

Turning to earlier Great Northern history, your correspondent, Mr. E. H. Livesay, in his entertaining articles on his Western Region gas-turbine rides, quotes the legendary saying of Patrick Stirling that "a coupled express engine is like a boy running wi' his breeks doon."

It would be interesting to ascertain by whom this saying was originally recorded. A modern writer has recently credited Mr. C. Hamilton Ellis with relating it for the first time.

While I have the greatest regard for the historical writings of Mr. Ellis, I can clearly remember reading that saying as a very small boy some time about 1913 or 1914. But I cannot remember where I read it. That was some twenty years before Mr. Ellis began to regale us with his fascinating railway histories. I rather imagine the story was first told by Mr. E. L. Ahrons, but cannot be certain as to this.

F. A. S. BROWN

Romford, Essex, October 20th.

The Institution of Engineers and Shipbuilders in Scotland

ON Tuesday of last week, Sir William Wallace, C.B.E., F.R.S.E., delivered his presidential address before the Institution of Engineers and Shipbuilders in Scotland, and recalled some interesting stages in the development of hydraulic equipment. He mentioned the old hydraulic cargo cranes for port and ship use and the latest cargo winches using the same medium, which have been installed recently. The beginnings of the hydraulic telemotor and steering gear were touched upon, also aircraft launching catapults, including the retardation mechanism employed in association with the latest steam catapult. Sir William went on to discuss ship stabilisers and associated problems and then turned to the problems facing the shipbuilding and marine engineering industries. After dwelling upon the country's economic position, especially with regard to our ability to pay for food and raw materials, Sir William said that we were not paying our way and deplored the continued demand for shorter hours and more costly social services. Out of the total population, only some 20 per cent acted as prime producers from whom the nation obtained the essentials of life. The president questioned whether the nation could survive unless there was a complete change of outlook throughout industry and remarked that very few of the suggestions contained in the productivity team reports could be used by industrial management. The main reasons for this were demarcation and restrictive practices, and Sir William instanced several examples of the high cost and loss of time involved by existing rules. These conditions were a handicap and Sir William maintained that a foreign shipbuilder had prophesied that demarcation might destroy Britain's lead as an efficient shipbuilding nation. Our position could not be viewed with complacency when the shipbuilding output of other nations was noted and Sir William concluded by saying that we had the inventive capacity and the skill to fashion and fabricate, but to survive, we must reorganise and produce saleable goods in the minimum of manhours as a step towards closing the gap between exports and imports.

THE LATE MR. L. BROOKE.—We record with regret the death of Mr. L Brooke, which occurred at Leeds on October 9th, at the age of fifty-nine. Mr. Brooke had been manager of the Leeds branch of W. T. Henley's Telegraph Works Company, Ltd., since 1937. He entered the company's service in 1926.

The Art of The Practical Engineer

By SIR DAVID PYE, C.B., M.A., Sc.D., M.I.Mech.E., F.R.S.

As is customary now for presidents of the Institution of Mechanical Engineers, Sir David Pye, in the address he presented last Friday and of which this is an abstract, drew upon experiences of his life, instancing in particular certain research work. We have chosen here, however, to print the provocative latter part of his address, in which he stresses that engineering is an art as well as a science, and criticises engineering education for its lack of attempt to give some experience of the reality of design procedure.

WHEN the question of my presidential address was first discussed it was suggested that an appropriate subject would be engineering education. I am happy to think that there are probably some members of my audience who have not read as many reports and letters to *The Times* on that subject as I have done. I tell you frankly that I shuddered at the thought of adding yet another address to the mounting pile of reports, memoranda, lectures and White Papers, with which any member of our education committee is already faced. I am afraid those concerned with technological education are getting a little tired of reports and addresses : we all know what we want to achieve, and if we do not know how to get it that is not for lack of papers and printer's ink.

I decided therefore that if I were to talk about engineering education it must be from a text of broad and simple significance drawn from my own experience, and that I must leave to the experts, at another time and place, important questions like the proper balance between the teaching of the fundamental and the applied sciences. Looking back on my experience, I ask myself whether I have a worth-while contribution to make. I think it is possible that I may have, because of my earlier experience in teaching young men how to pass examinations in engineering subjects, followed up later by the years during which I occupied a ring-side seat, as it were, watching the real work of designing and producing in the shops the new things that were to change the course of engineering ; these two periods have left me with a profound sense of the yawning gap between the product of a university course and the qualified engineer, and —more particularly—of the importance in any organisation of the man of whom one feels that he is by nature an instinctive engineer, though it may be with little or no scientific training as ordinarily understood.

Of course, none of us ever imagined a student and an engineer to be the same thing. Before he can be an associate member of this Institution, the university graduate must have supplemented his theory by practical training and responsible experience ; and this combination may provide the basis for his becoming a real engineer. But I have been led to feel how small a part of the way all the theoretical training, in which we teach him to manipulate formulæ on paper and to record experiments in a laboratory, can ever take him : by the time he has " grown up " as an engineer, indeed, his book learning will have become hardly more than a vaguely felt background to his experience. For the art of engineering includes a very great deal that lies outside of formulated theory. The rule-of-thumb plays, and will always play, an important part, and rules-of-thumb are accumulated by experience.

I have said that all engineers know what they want to see achieved by engineering education : I take that to be a young generation coming forward eager to take responsibility and competent to do so *at all levels*, each in his proper sphere. I emphasise " at all levels " because, although the majority of those who are vocal on the subject of engineering education tend to come from the universities, and are apt to concentrate upon training at the higher levels, I suggest that the technical and technological manpower of the nation should be thought of as a whole : beginning with the skilled craftsmen, and including draughtsmen, designers, research and development staff—junior and senior and those who become managers and directors. Men of special quality are to be found at all levels, and it should be the constant aim of those in authority to spot them early and to bring them forward to the maximum of their capacity.

I want to take as an example designers ; not because I have ever been a designer myself but because I doubt whether more than a very few of the able men who are teaching at universities and technical colleges normally reflect much on the work of a design section, which is the creative centre of any works, and because what I shall call the creative designer may begin to show his quality when he is a junior draughtsman, and the creative spark is precious and must be fostered above all things.

Fig. 1—Shrouded Impellers of " Proteus II " and " Hercules " with the Forgings from which they were made

Recently I was at a small works where you might say that the spirit of design was rampant ; where they produced the most complex machines and seldom built more than two or three of the same type. I asked the managing director : " How do you recruit your designers for this sort of design work ? " His reply was that for the most part they were recruited direct from school. Continuity of employment, of course, was an essential factor ; within a year or two a few of the recruits began to show the necessary spark of originality for promotion to group leaders, and ultimately to designers and above.

It is obvious that these men, who come up the hard way, must have constantly before them the essentially positive aim of the engineer : to devise and construct something that is better for its purpose, whatever that may be, than that which has existed before. While they are gaining their background at evening classes, these budding designers have all the time the stimulus of meeting known requirements. Now it is just this positive aim of the engineer in his profession about which, as it seems to me, there is a fundamental difficulty in the presentation of any real picture as a part of a university course. A university, it is true, is a place of learning and research, but it presents itself so often in the mind of the student as a place where he has to acquire a degree in the shortest possible time. That does not make the atmosphere conducive to the blossoming of a flair for ingenious design ; nor are university examinations the circumstances in which it would be detected. They do not lend themselves readily to the assessment of a man's quality as a designer, and there appears to be a danger that where there is no clear method of differentiating between the good and the poor student, the teacher and examiner may lose interest in design as a subject in the award of a degree—quite apart from the fact that the teachers and examiners are for the most part themselves of an analytical turn of mind ; skilled in those methods of research whereby such mighty results have been achieved, but only incidentally interested in new opportunities for design and construction.

The atmosphere of a laboratory is fundamentally different from that of a design office, which should be more like an artist's studio or an architect's *atelier*. In a design office, things are not right or wrong : trial and error lead gradually towards the best compromise in the special circumstances. And since compromise is fundamental in the solution of almost every engineering problem as it occurs in practice, the student at some stage should be made familiar with it. There is a real danger in concentration upon the " examples class " ; admirable as it is for testing the understanding by a student of what he has been taught, and for the exposure of muddled thinking. But deadening to originality of thought. In working out examples the student employs well taught mathematical techniques to find the solution of problems that are analogous to those in engineering, but different in form from those encountered in practice.

The growing tendency to-day is to recruit from among those who have taken university degrees ; we may perhaps assume as a working hypothesis, but with many notable exceptions, that as a class the ablest recruits to the engineering profession find their way to the universities. We should therefore look to the universities to feed back into industry first-class minds with a well-balanced scientific and technical background ; many of them minds that are ready to be stimulated to creative activity by contact with the practical needs of industry. Are we choosing the right way to set about the task of providing the needed background while at the same time retaining sufficient flexibility in the courses to allow the spark of originality, when it exists, to grow ? I have touched already upon some of the fundamental difficulties of what I have called a more positive approach to engineering education as contained in a degree course ; but even if one cannot hope to introduce the atmosphere of a design office it would be something achieved if the university student could be made more aware of the importance of design in the progress of engineering. I know of a few courses of university standing where a serious effort is being made, chiefly at the post-graduate stage, to introduce some of the realities of the design office to a small team of students ; but it is always subject to the handicap that the atmosphere of discussion and compromise can

become real only if it is confined to a small group. Ideally the group should be organised by a man who is actually engaged in responsible design work himself; he is therefore not primarily a teacher and serious difficulties of administration are introduced.

Nevertheless, the problem should be faced. Can it be said that the creative mind is typical of the university graduate in engineering to-day? If it is not, can this deficiency be laid to the charge of the courses provided, and are there any practicable modifications by which the position can be improved? To my mind questions should first be asked about the methods whereby selection is made of those young men who are to be allowed to embark upon honours degree courses. I would suggest that this selection is in danger of being left too much in the hands of the mathematicians. Some chemistry and physics may form part of the qualifying examination; but it is a candidate's ability in tackling the mathematics that is often crucial. Mathematical tests are ideal from the examiner's point of view; easy to set and easy to mark; producing a definite order of merit, easily translated into first, second and third-class honours. But indicative of what? Not, certainly, of the seeds of a creative or instinctive engineer.

The mathematical test contains no element whatever of the positive approach to engineering education that would from first to last place *some* emphasis upon the ultimate aim of the engineer; which is to devise and construct. Do not imagine I am belittling the importance of mathematics as the basis of an engineering education or, at its higher levels, as equipment that may be essential for some research engineers. All I am suggesting at present is that to rely upon competence in mathematics for the selection of young men to be admitted to an honours course in engineering is to risk the exclusion of quite a number who might have developed into the finest engineers. There are those who do not take kindly to the mathematical approach, and they should not be thrown out at the first hurdle. Under present-day arrangements, and with the mathematical standards now expected, it is largely true to say that the mathematicians decide who shall be our future university-trained engineers. And this is the more dangerous if it is true, as several men have assured me they believe, that a moderately clever and hard-working boy in the hands of an able teacher can be coached in mathematics to show a form in an examination that is quite unreal as an indication of his general intelligence.

An understanding of the processes of mathematics up to, say, the solution of first-degree differential equations is desirable as forming part of the normal shorthand used in engineering education. At a much higher level, mathematics can be a powerful tool in the hands of anyone competent to use it. But it would be, in my opinion, wise to keep the two categories of mathematics quite separate, and to encourage only those young engineers to whom it comes easily, as a friendly tool, to attempt to go beyond the stage of understanding it as a form of shorthand. For it is only they who will be the better engineers for the study of it. If the mathematicians are allowed to get the bit in their teeth and go galloping off with half of their unfortunate students trailing behind, unable to keep up, then the only benefit those students will ever get from their higher mathematics will be a few odd marks at their final examination, at the price of many wasted and painful hours that might have been much better spent.

Having made our selection of those who are to be given the elements of a basic training in engineering subjects—in machine design, prime-movers of various kinds, hydraulics, and applied electricity—we proceed in most engineering courses to put the young men into a mental "strait jacket" in which for a year they study mathematics, physics, chemistry and machine drawing, with scarcely a hint of real engineering to encourage them. In the second year they are taught to apply scientific techniques to the solving of simple engineering problems, and at the same time to enlarge the scope of their analytical work—which is to come in the third year—by reading and descriptive exercises. The third-year work is devoted almost entirely to the solution of problems analogous to those which arise in engineering practice; and the solutions of nearly all these problems involve mathematical techniques. The students who reach their final year, therefore, do so by passing tests and examinations in technical and scientific subjects only, and there is no

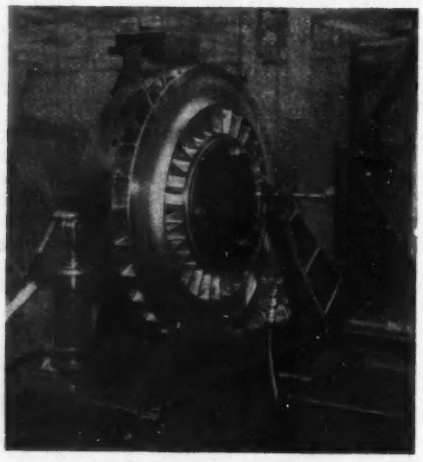


Fig. 2—Milling the Front Pocket in "Proteus II" Steel Impeller

place in many university engineering departments today for a man who has not acquired the technique of mathematical analysis in the solution of technical problems. He may never have been brought into touch with design as the living stimulus towards improvement of function. All the pressure of an over-full programme is brought to bear upon the somewhat sterile pursuit of solving artificial problems in engineering, invented for examination purposes.

I speak as one who has had no direct contact with engineering teaching for many years, and perhaps I should hold my peace. But I have had many discussions with engineering teachers, and have compared modern examination papers with those of my own student days. Current papers reproduce the character of their predecessors of forty-five years ago with extraordinary fidelity, except in details and except for the higher standard of mathematics often expected. Moreover, professors whom I have consulted have told me that, whereas when they were themselves students time was spent in going through the steps of actual designs, of late years pressure on the time-table from all sides has forced them to cut out even those attempts at a positive approach. To work through the steps of a design will not carry a class very far towards the realities of a design office; but must even *these* attempts to retain some constructive element in the training of our best students be abandoned? Cannot time be found if we are sufficiently drastic with the present time-table? You could turn out a very good engineer by teaching a man nothing but physics, with some chemistry and mathematics (not too much unless he is a natural mathematician) and engineering drawing; and by leaving all the rest that he finds he needs in practice to be picked up by post-graduate reading.

My impression, for what it is worth, is that many university courses have become overcrowded and stereotyped and lack the flexibility to allow for the exceptional man. I know of a few teaching departments of university rank—but I believe them to be a small minority—where a serious attempt is being made to give some experience of the reality of design procedure. In too many engineering courses, however, we seem to be making little attempt to develop more than one side of an engineering student's work—the analytical and mathematical one—and not to be giving the potential works manager, or the administrator, any greater opportunity to show his quality than that given to the designer. In this connection the interesting innovation at Durham University described by Professor Burstall to the British Association a year or two ago is of particular interest.

My final remark in this connection—deliberately provocative—is that I deplore the almost pathetic faith shown in the advertisements from all Government departments (and some research associations, who should know better) in the first or second-class honours degree. May I suggest that there are jewels to be found, by those who will take the trouble to look among the supposed refuse of third classes and passes. An ounce of instinct is worth a pound of information.

I have called my address "The Art of the Practical Engineer" and I have spoken of the "art of engineering" because I want to insist that so much of the work of the designer, in mechanical engineering especially, calls in practice rather for the instinctive skill of the artist than for the calculations of the mathematician. As an example of what I mean, Fig. 1 illustrates the fully-shrouded impellers of the centrifugal superchargers in the "Proteus" jet engine and the "Hercules" piston engine. In front of each is the forging—the one in steel, the other in aluminium alloy—from which each impeller is produced from the solid by a continuous milling operation. The relative movements of the work and of the cutter are controlled automatically so as to provide an almost continuous machining process throughout. Fig. 2 shows a milling machine in operation on one of the front pockets of the steel impeller.

I should perhaps explain, for the benefit of those not familiar with centrifugal superchargers, that air enters the impeller in an axial direction—parallel to the shaft—and leaves it in a direction at right angles with the shaft, through the slots round the periphery of the wheel. The steel and aluminium alloy impellers revolve at speeds of about 12,000 r.p.m. and 20,000 r.p.m., respectively, and the efficiency of the superchargers depends upon the exactly correct shaping of the passages, which in these designs have to be milled out of the solid forging.

I think you will agree that the mind capable of conceiving and designing the milling machine to carry out the extremely complex movements involved exhibits an imaginative power of a high order. Mathematics, apart from simple arithmetic, has no part to play. There is an engineering intuition required in such a design, something born of experience, which arrives at conclusions by no traceable process of analysis as to what

can or cannot be made to work. Such an instinct goes a long way towards the make-up of the "creative engineer," or the man with a touch of the artist in his composition. Here I have used the words "artist" and "creator" as almost synonymous terms, and indeed I think that every artist must be, in some sense, a creator.

Normally, when we speak of art or of an artist, we think of the fine arts—drawing, painting or sculpture—and it is perhaps worth pointing out that the creative engineer and the artist have this in common: that just as the engineer without detailed knowledge of his materials is like a blind man groping in the dark, so the painter or sculptor is helpless, dumb, until he has a knowledge of his materials and what can be done with them—whether paints or marble—which is so intimate that he can make them express not only his concrete needs but his ideas also. The engineer is not as a rule called upon to express only ideas in his creations; although certainly the engineer who designed and built the Skylon at the South Bank Exhibition last year may be said to have done so, and he—quite as much as the painter and the sculptor—would have been helpless without a very accurate knowledge of his materials. If you are going to create something, whether it is a work in one of the fine arts or a locomotive, an essential prerequisite is complete familiarity with the materials to be used in creating it. That is universally true.

The supreme phenomenon of the creative engineer is found when a designer of genius appears, almost untaught. The classic example must surely have been Sir Henry Royce. As a young man he became a tester in one of the new electric lighting companies of that time—strange training indeed for the inspired designer of aeroplane engines whose genius enabled this country to hold the speed records of the world, by land, sea and air, all at the same time. Of course, his inspired faculty for designing complicated mechanisms was based on sound science; but he was largely self-taught. In all he did his work showed unusual exactness and thoroughness, and he had a phenomenal memory. He once remarked, in reply to an inquiry: "My night-school education made it imperative never to forget anything that was worth remembering, and I have never outgrown the habit." He was always intelligently absorbing and selectively remembering, so that in time he acquired that distilled wisdom which is garnered from wide experience and held ready to be applied to each new problem as it arises.

Royce was a man who reached his mature skill as a designer almost without formal training. Our great benefactor, James Clayton, in the field of textile machinery, was another. Such men are rare, and with the growing complexity of engineering are likely to become rarer still, for it is only men of genius who can now survive the handicap of an absence of early training. But if we go outside the class to which the word "genius" can apply there are many men, both trained and untrained, who have a certain audacity of imagination, or peculiar perceptiveness, which puts them into a special class. And such men may appear, as we have seen, at all levels. They may or may not show originality as designers. There are other ways of being classed as a creative engineer. I have in mind, for example, a man who was in charge of the test-beds at a well-known works; an uneducated man, but one with an uncanny instinct for machines. If anything were going wrong, and puzzling those responsible, it would always be worth while to give this man his head. He would often "scent out" the trouble after trying this and that; sometimes for what appeared to the experts to be faulty reasons. It is this kind of instinct which, in taking a broad view of engineering training, we should strive to preserve and develop no less than that of the successful designer. I have in mind, too, another type of man whose skill may be of peculiar value within a limited sphere, a typical product of the works floor: the man of supreme skill of hand in some specialised line; the manipulative wizard, one might call him, whose work has no more of the creative faculty than that of a juggler, except possibly for creating records of speed in manipulation. And his skill is valuable only if it cannot be copied and multiplied by machines. Sometimes it cannot, and the man gets his proportionate reward.

Apart from such men with special qualities of instinct or skill, I come back to the man who has the truly creative faculty of the designer. When discussing design one should speak not of an individual, but of a team; though a team with an acknowledged leader. Probably there is no department in a works where leadership is so important, or where the stimulus of one man may be so widely felt, as in the design office. And in speaking of the creative designer one must not forget to mention, in passing, his natural complement: the wise man of varied and long experience, the critic rather than the originator. One might perhaps suggest that every successful team must have its *advocatus diaboli*; its critic as well as its creator; the successful practitioner to balance the brilliant originator, the latter always fertile and the former patiently backing him up and getting the best out of any novel design. Sometimes, of course, the qualities of the innovator and the successful practitioner are combined. One suspects that they were so combined, for example, in Sir Charles Parsons. Genius as a designer in many fields he certainly had; and also the wisdom of the successful practitioner; but who knows there was not also a valued critic in the background?

All these men practise the art of the engineer: to devise and create. And along with our designers of genius and our successful practitioners we must cherish also those types one may meet in any works from time to time; men who would never have passed the first of the examinations considered essential among the qualifications of an engineer, who may give the wrong reasons but will find the right answers. They within their range are, like the great ones, guided by an instinct that seems to achieve a distillation of relevant experience and can be counted upon to solve a practical problem in the most direct way.

Institution of Naval Architects

AUTUMN MEETING

No. III—(*Continued from page 524, October 17th*)

THE Autumn Meeting of the Institution of Naval Architects, which was held jointly with the A.T.E.N.A. in Italy, was continued in Rome on Monday, September 29th, when the delegates met at the Consiglio Nazionale delle Ricerche (National Research Council), Piazzale delle Scienze. The members of the conference were welcomed by Professor Fea, on behalf of Professor Gustavo Colonnetti, the president of the Research Council, who recalled the hospitality extended by the British Institutions during the International conference of Naval Architects and Marine Engineers held in Britain last year. Lord Runciman briefly replied and voiced the thanks of the Institution of Naval Architects.

Before proceeding with the reading of the papers there was the ceremony of presenting the Diploma of Honorary Membership of the Institution of Naval Architects to General Giuseppe Rota. In making the presentation, Lord Runciman mentioned that General Rota had been a member for fifty-five years and was a contemporary of Froude and Taylor. Continuing, the president recalled that the General's latest contribution to the science of naval architecture was made more than fifty years after his first notable work. He went on to mention General Rota's work at the Spezia and Rome tanks and to recall his papers on contrary turning propellers and the fundamental work on the influence of depth of water on ship resistance. Owing to illness, the General was not able to attend the ceremony and the Diploma was received by his daughter on his behalf.

Dr. Della Razione, the Presidente of the Associazione Italiana di Tecnica Navale, honoured the Institution of Naval Architects by presenting Lord Runciman with a Diploma which made him the first Honorary Member of the A.T.E.N.A. Lord Runciman was also presented with a model of an anchor, used by the State Barges of Lake Nemi some two thousand years ago, as a symbol to emphasise the close links between the A.T.E.N.A. and the I.N.A.

Upon the completion of the ceremonies, the technical proceedings in Rome were opened with Lord Runciman in the chair.

The first paper to be presented was :—

EFFECT OF PITCH AND BLADE WIDTH ON PROPELLER PERFORMANCE

By R. W. L. Gawn, O.B.E., R.C.N.C.

SYNOPSIS

Results are given in a series of diagrams of the tests of thirty-seven propellers, each having three blades, covering a wide range of pitch ratio of 0·4 to 2 and of blade area ratio from 0·2 to 1·1 Each model was of 20in diameter, and tested at high duty from zero to 100 per cent slip.

Thrust and torque coefficients increase appreciably with pitch and generally, but to a lesser extent, with blade area. The most favourable peak efficiency is 0·84 appropriate to the greatest pitch and narrowest blade, while peak efficiency is least for the smallest pitch and widest blade tested and is less than one-half of the optimum. No significant improvement in peak efficiency is expected from an increase of pitch ratio above the largest of 2 covered by the series. More favourable peak efficiency is expected by reduction of blade area ratio below the lowest test value of 0·2 but the blades would then be exceptionally narrow, the width being limited by cavitation.

Theoretical deductions indicate that laminar or transitional flow has been avoided and that the critical Reynolds number in this respect is a quarter of a million. The tests extended to a number of 4·3 million and one upshot of this considerable advance is that the results may be expanded to ship propellers with only a small correction for skin friction resistance. Peak efficiency of ship propellers may be a little more favourable but this is subject to smoothness of finish.

Departures from the results of previous series are noted which may be due to scale effect and differences in design. The investigation may prove useful as one step in the clarification of scale effect

of propellers to which importance is attached by the International Conference of Ship Tank Superintendents.

Discussion

Dr. J. F. Allan : This paper represents the completion to a certain stage of a programme of work which the Admiralty Experiment Works embarked on some considerable time ago and it is very comprehensive in its scope as regards range of pitch ratio and range of blade area ratio, while the scale of the experiments should please the most critical in regard to the scale effect question.

I criticise the use of segmental blade section shapes but probably further programmes will use more modern sections.

The standard method of testing at 500 r.p.m. and varying the speed of advance, is something to be adopted. Mr. Gawn states that he varied the r.p.m. in order to explore the effect of the older method of testing model propellers, using a constant speed of advance at varying revolutions, but he does not tell us what he has discovered.

When running at constant revolutions and varying the speed of advance with the high pitch ratio propellers, the loading on the blades must have been quite considerable and with the bigger area ratios there may have been some distortion. Were any observations made in that direction ?

From the diagrams it is noticeable that at the lower pitch ratios there was curvature on the KT and KQ curves, whereas at the middle pitch ratios they are almost straight lines. At the low blade area ratios there is a marked curvature on the KT and KQ curves, whereas at the high blade area ratios they are almost straight lines and show some peculiar hollows. I wonder what the explanation might be.

In the diagram showing the outline of the model propellers I wish to draw attention to the fact that the low area ratio screws are exceptionally low. These are segmental sections, having a very high thickness ratio, approaching 40 per cent. Thick segmental sections are subject to a very serious circulation scale effect, apart from friction scale effect, and it is possible that, in spite of what the author endeavours to demonstrate to the contrary, there was an appreciable amount of circulation scale effect on the inner sections of the low area screws.

The questions of laminar flow on propellers and of what is the minimum Reynolds number at which we can safely predict for the ship have been receiving attention on an international basis. The author's diagram showing profile frictional drag coefficient is interesting and it appears to indicate that if a Reynolds number of about a quarter of a million is exceeded we should be free from the worst effects of laminar flow, and that is very valuable confirmation to have. We are studying the question of laminar flow on model screws and have seen indications of laminar flow at much lower Reynolds numbers than a quarter of a million, but because there is laminar flow there will not be necessarily any major influence on the forces ; there are balancing factors.

Dr. G. Giliberto : I would point out that an important factor in the study of propellers is the number of blades. For a certain series of values of blade area ratio, as compared with a smaller ratio, a propeller with more blades—say, four—can have an efficiency higher than a propeller with three blades, because it is easier to avoid the effect of cavitation.

Why not increase the number of blades in order to avoid using large blades and in order to ensure a distribution of the thrust when the propeller is loaded.

I should like to ask why Mr. Gawn did not test propellers with an aerofoil section, and also what importance he attaches to the theory of circulation.

Dr. Ir. W. P. A. van Lammeren : My comments are an endeavour to throw some light on the activities of the Wageningen ship model basin with respect to the research on systematic propeller series which is now in hand, to stimulate further relevant research and, if possible, international co-operation in this field.

The propellers dealt with were of segmental blade sections, and although this has the advantage that the results can be compared with the former series and the well-known series of Taylor, surely the efficiency could have been improved by applying, especially in the vicinity of the boss, aerofoil shape sections. The comparatively large efficiency values of some of the propellers leave little room for improvement but comparison of the efficiency curves of the Wageningen B-series propellers tested at a much smaller Reynolds number, with those of the new Gawn series, at advance coefficients less than those corresponding with peak efficiencies, leads to the conclusion that some improvement might be possible by the application of more modern sections over a certain part of the blade, especially with the smaller pitch ratios and blade area ratios.

Although the cavitation characteristics of segmental blade sections for the larger blade area ratios are not bad, improvement may be possible by applying the modern constant pressure profiles with shock-free entrance, the so-called Karman-Trefftz sections. The Wageningen ship model basin has set up a systematic series of three- and four-bladed propellers having Karman-Trefftz sections at the tip and aerofoil sections near the boss. The diameter of the bronze models is 42cm (about 16in), and tests in the cavitation tunnel as well as in open water are planned. Five models are being cast, and it will be possible to remake them with the same dimensions as those of the author's series and to test them under the same conditions. A direct comparison of the results with those of the basic series used by the author would then be possible. I should like to offer the author the opportunity to test his propellers in our cavitation tunnel, if the Alpax alloy can stand the greater forces imposed. The tests could be carried out at the same Reynolds number, and also at a higher Reynolds number, so that the scale effect, if any, could be determined.

I ask whether it would be possible to give the results of the tests in the well-known form of B_p–δ diagrams, which form is so suitable for the propeller designer.

Professor A. M. Robb : One difficulty in all experiments with propellers is that you cannot vary a secondary variable without at the same time altering your primary variable. In the diagram showing propulsive characteristics Mr. Gawn purports to show the effective blade area for constant pitch ratio, whereas in fact he does not do so. From the diagram you will see that when you alter the blade area you alter the effective pitch ratio. The pitch ratio is not 1·2 but the effective pitch ratio, which varies from 1·26 to 1·47, so that the curve is misleading to that extent.

I looked at the results from the effective pitch ratio point of view in order to get a comparison with Froude's results of 1908, and to find out whether the very simple Froude, 1908, relations for the effective blade area and pitch ratio were valid. A fairly simple analysis shows the Froude relation for the effective pitch ratio is not valid and with regard to the validity of Froude's blade factor, the results mean that we have to throw Froude's blades back to the wind. The effective blade area is much better than is suggested by Froude's blade factor.

Mr. Gawn said that variations in speed have no material effect, but if he is satisfied with that he is completely at variance with a large body of experimental workers, starting with Taylor in 1906. I suggest it is of no use talking about scale effect until you clarify the law of comparison.

Professor E. V. Telfer : We have here a piece of experimental evidence which is exceptionally valuable and useful, subject to the neglect of Reynold's law and of Froude's law.

I would like the author not to emphasise the enormity of the gap existing between the model and the ship because, as the result of his advice, the Admiralty is prepared to design its propellers. I suggest this because of the successful experience we have enjoyed over the last eighty years, since Froude introduced the subject, that the gap does not exist, and any emphasis on the gap is misleading the experimenter.

The behaviour of the thrust line at the higher blade area ratios is curious, since instead of having the uniformly convex form, you have a re-entrant type. I doubt that that actually takes place, because I doubt that the draughtsmanship of the diagrams is necessarily 100 per cent. Would Mr. Gawn give the complete experimental spots for one particular screw and show how these re-entrants can be justified? If the scatter of the spots is so small that he can justify his statement, he has discovered a most important phenomenon.

Mr. A. J. Williams : The advance coefficient curves completely define the performance under non-cavitating conditions of a very large family of three-bladed propeller shapes.

In the design of a propeller to meet specific requirements the choice of blade area ratio is not as simple as the curves suggest, since the efficiency of propellers of small B.A.R. is impaired by cavitation. Mr. L. G. Bell has shown in his paper to this Institution in 1947 that for the propellers of a fixed P/D ratio there is an optimum B.A.R. which depends upon the cavitation number, the most favourable B.A.R. being high for low cavitation numbers and vice versa. He also showed that the effect upon efficiency of varying the B.A.R. is not critical, so that the designer's task in selecting his B.A.R. is not onerous.

Could the data given in the advance coefficient diagrams be replotted, using different parameters, so that the factors being sought are presented explicitly rather than implicitly ? The part of each KT curve normally required is that for maximum efficiency, which occurs when KT is comparatively small, and perhaps the re-plot could be made so as to magnify the parts of the KT curves normally used, thus increasing the accuracy of their interpretation at the expense of the data for high slip, which is less frequently required.

Professor L. C. Burrill : This paper is factual and, therefore, there is not much very controversial discussion to be raised about it, and the results will be useful mainly for the higher blade area ratios above 0·65. Without criticising the results of the lower blade area ratios, it is for the higher blade area ratios that this type of section and this type of propeller with three blades might become appropriate.

I suggest that, if the Admiralty will agree, it would be helpful to give us a four-bladed screw series to go alongside the three-bladed series. I also suggest that the existing screws, having a high thickness ratio, be reduced in thickness at the root to give the effect of thickness so that we can interpolate between one thickness ratio and the other.

The range of these tests is excellent, the size of the propellers is good, and in that respect it is a return to Taylor's work. Taylor used quite large propellers in his early experiments and for that reason his results have been very useful. The Reynolds number is satisfactory and, contrary to the earlier series to this set, the boss size is in keeping with the normal boss of ship propellers.

I welcome the change in presentation, perhaps international agreement has forced us to use it, but the *KTKQ* method of presenting the results is better than the Froude system, which was difficult and lengthy to examine.

With regard to the remarks of Dr. van Lammeren, I suggest that he might give part of the picture in the B_p–δ presentation. I am quite sure that if he does not do it now, somebody will.

The diagram giving the effective pitch factors for the various blade area ratios and pitch ratios, is perhaps the most valuable in the paper. It indicates the effect of pitch ratio on effective pitch, particularly at the low blade area ratios of about 0·4 and 0·5, which is the region in which merchant ship screws are being designed. It will be interesting to compare it with the 1937 diagram and also with various formulæ which have been put forward, and if we are satisfied with it, it will solve many problems in regard to the thickness of propellers.

The statement that the designer interested in maximum propeller efficiency should aim at a large pitch associated with small blade area, needs a great deal of modification. It takes us back to 1907 or 1910, when many people were misled by this general statement concerning high pitch ratio. Taylor has taught us that the designer must not try to get a high pitch ratio. For each set of revolutions, speed of advance and power there is an optimum diameter.

In the diagram comparing the results of these tests with those of earlier tests on a similar type of screw, and also with Troost's aerofoil section screws, the differences shown may be due to the apparatus, scale effect or a boss change. I think Mr. Gawn has taken the boss off so that the results are comparable with those of Troost. I believe it is principally scale effect, and it is the larger round-back screw which is coming into line with the aerofoil type.

The difference between the 1952 and 1937 figures is of interest. Taking a typical figure in the middle of the diagram ; I believe that in 1937 I was going to work on an efficiency of 60 per cent, and I can get 64 per cent with some little change.

I agree that we can use these figures without correction for scale effect in passing from the model to the ship, but no propeller is designed to sit on the peak of the curve. The peak of the curve to a base of J or δ is not the real peak. It should be to a base of B_p.

Mr. Gawn replied, and said : With regard to the presentation of the results, the coefficients chosen and the methods of presentation are those agreed internationally, and one cannot produce various sets of curves covering the same data in different forms in one paper.

As a propeller designer I have never used B_p–δ, so that I do not think I could persuade the Admiralty that I should plot in that form. What we have done for our own designs at Haslar to supplement these curves, is to plot on a base of *KTKQ*, which is the form in which we have always used our propeller results for many, many yeras.

I am in sympathy with those who have spoken in favour of using effective pitch ratio as a basis for plotting, but it is not in accordance with the international agreement. It has solved many problems, and I have included curves for effective pitch ratio in the paper and have shown how they can be used.

I would like to think over the suggestion made by Dr. van Lammeren that propellers could be tested in the cavitation tunnel.

Tests on small-bladed propellers, thinner and thicker propellers, have been done, but one cannot get all the results in one paper. It has been asked why not thicker blade sections, and why not modern sections, and I claim that these are modern sections. When you come to lower blade area ratios it is quite clear that a designer interested in a propeller would like to modify the section at the root, if nowhere else, but I am interested in preserving geometric similarity for this series, which is so important.

Professor Telfer suggests that the experimental spots should be added for one particular screw. I am confident that would show up remarkably well, and with the Council's permission I hope to add the diagram.

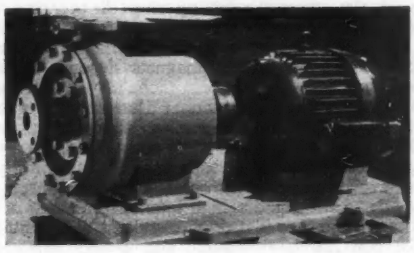
(To be continued)

A Glandless Centrifugal Pump

WHEN it is required to pump a number of the liquids handled in the chemical and allied industries, difficulty is often experienced in the fitting and maintenance of glands, particularly where it is essential that no leakage or trace of leakage should take place. In order to overcome the difficulties and special conditions—such as are encountered when handling corrosive and toxic liquids, and operating at high temperatures, high vacuum and high suction pressures—a glandless centrifugal pump has been developed by Mr. G. J. E. Howard. This pump is now being made by Hydraulic and Mechanical Developments, Ltd., of 116, Victoria Street, London, S.W.1. In the pump, drive is transmitted by a permanent magnet coupling through a metal sealing shroud which dispenses completely with any form of shaft sealing gland.

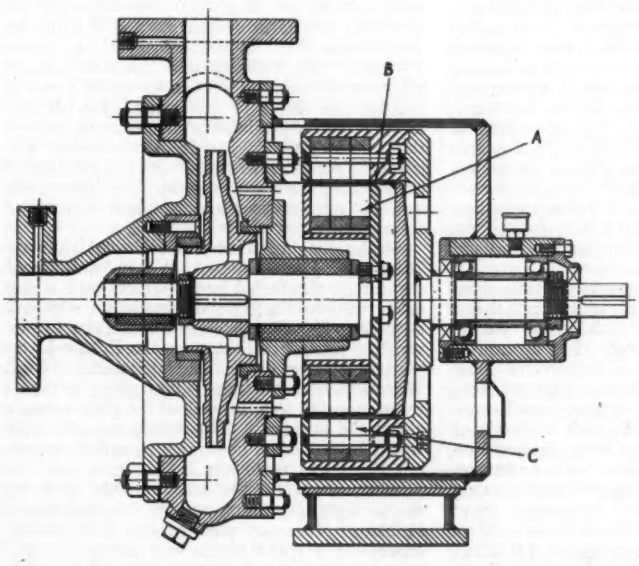
The principle upon which the coupling operates is quite simple. It makes use of two rings of horseshoe-shaped permanent magnets, the inner ring being mounted on the pump impeller shaft and the outer ring on the driving shaft. The magnets on the driving shaft have their poles facing inwards, and those on the driven shaft have their poles facing outwards. In the gap left between the magnets a sealing shroud is introduced. This sealing shroud of corrosion-resisting steel completely encloses the driven magnet ring and is bolted to the side of the main pump casing. To protect it from the effects of the liquid being pumped the inner ring of magnets is enclosed in a metal housing. It will be appreciated that as the outer ring of magnets is rotated it drags the inner ring round with it, so that the two rings of magnets always rotate in step.

The arrangement of one of the firm's 1½in glandless pumps is shown in the drawing on this page and the photographs we reproduce. It will



Glandless Pump Unit

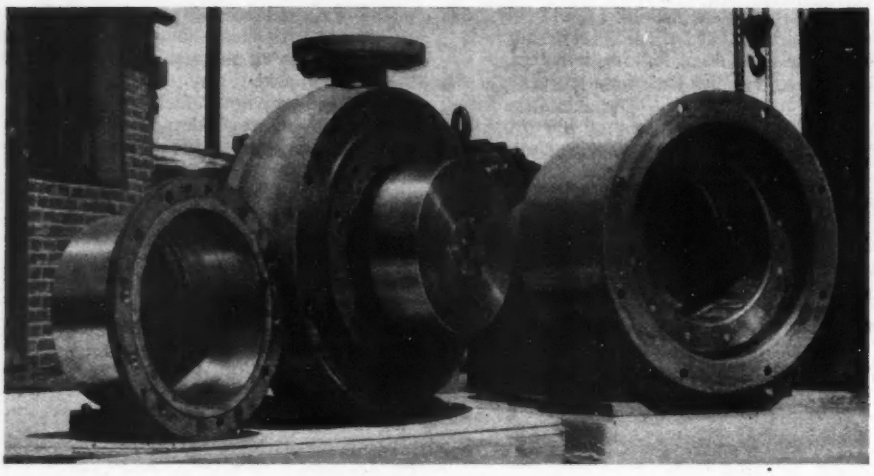
be seen that the impeller is carried on bearings in the front and back of the pump body. These bearings, which operate in the liquid being handled, can be made of any suitable material, such as cast iron, bronze, carbon, &c. To an integral flange at the rear end of the impeller shaft is bolted the back plate of the driven magnet ring *A*. The ring of magnets is spaced round an annular chamber carried by the back plate, and the magnets are held rigidly in position within this sealed chamber by bolts and a plastic filling material.



Sectional Arrangement of Glandless Pump

The sealing shroud *B*, which completely encloses the driven magnet ring and back bearing assembly of the pump, is bolted by its rigid reinforced flange to the body of the pump to form a liquid and gastight seal. Both this sealing shroud and the inner magnet ring are made of austenitic stainless steel, or a similar material with high corrosion-resisting properties.

The ring of driving magnets *C* is mounted in an annular chamber over the shroud, and its back plate is coupled to an intermediate driving shaft. This shaft is supported in ball bearings carried in the boss of a substantial fabricated housing which surrounds the complete coupling assembly, and



Pump Sealing and Drive Components

provides a supporting member for the pump unit.

One of the illustrations shows a pump unit complete with its driving motor, and the other the principal components of the drive and the shroud. In this second photograph the shroud is shown on the left-hand side of the pump and the sealed inner ring of magnets can be seen bolted to the impeller shaft. In the main drive housing shown on the right of the pump can be seen the outer or driving ring of permanent magnets.

It will be appreciated that in this drive the torque exerted by the magnets depends upon the size of the gap between them. By increasing this gap with a proportional decrease in torque the thickness of the sealing shroud can be increased, and in this way a coupling can be produced which is capable of transmitting appreciable power through a sealing shroud made to withstand a high internal pressure. At present the firm is making couplings to transmit 20 h.p. at 1500 r.p.m., and proportionately higher powers at higher speeds.

The makers point out that the Howard magnetic coupling can also be applied to fans, compressors, agitators, &c., or wherever it is required to transmit power through a sealing shroud.

Harrow and Wealdstone Train Accident Inquiry

THE Ministry of Transport inquiry into the railway accident, which occurred on Wednesday morning, October 8th, at Harrow and Wealdstone station in the London Midland Region of British Railways, was opened in London on Wednesday of last week by Lieut.-Colonel G. R. S. Wilson, the Ministry's chief inspecting officer of railways. At the outset of the inquiry, the accident was described by Mr. S. G. Hearn, chief operating officer of the London Midland Region. As a result of the accident, 112 people lost their lives, 109 of them being passengers and three members of engine crews, and over 160 people were injured. Of the casualties, thirty-seven of the killed and ninety-eight of the injured were employed on the London Midland Region of British Railways.

Mr. Hearn stated that a passenger train from Tring to Euston was standing at the up fast line platform at Harrow and Wealdstone station when it was run into from behind by an express passenger train from Perth to Euston, travelling at speed. Before any protective measures were possible, another passenger express, from Euston to Liverpool, approached at speed and collided with the wreckage caused by the initial accident. The local train from Tring, Mr. Hearn continued, consisted of nine vehicles, weighed approximately 251 tons and was estimated to contain about 800 passengers. On the Perth-Euston express there were about ninety passengers, the train, which weighed 364 tons, consisting of eleven vehicles, of which four were sleeping cars. The Euston-Liverpool train, headed by two locomotives, consisted of fifteen vehicles, of which four were vans, and weighed about 444 tons. Its passenger complement was put at 186. Altogether, Mr. Hearn said, fourteen coaches were demolished and the locomotives involved were severely damaged. The weather was fine with some patches of mist.

The witnesses examined on the first day of the inquiry included Mr. A. G. Armitage, the signalman at Harrow No. 1 box. Mr. Armitage said that on taking over the box at 6 a.m., it was dark and inclined to be misty ; fog regulations were not then in force, but he put them into operation at 6.35 a.m., when the mist thickened. Mr. Armitage went on to describe his acceptance of the trains involved in the first collision, saying that he could tell by the sound of the Perth-Euston express that it was travelling at speed and was not obeying the signals. It made no attempt to pull up. He immediately applied the emergency detonators on the up fast line, his second action being to protect the Euston-Liverpool train by replacing the signals on the down fast line to danger.

When the enquiry was resumed on Thursday of last week, the guard of the Perth-Euston express, Mr. J. Kent, said that the train was running about 90 minutes late, and that at the time of the collision he estimated its speed to be between 50 and 55 miles an hour. The first indication he had of anything amiss was a severe application of the brake, which was a matter of seconds before the collision occurred. Mr. Kent said that he did not hear any detonators. Mr. S. Williams, signals and telecommunications engineer in the London Midland Region—who was a passenger in the train from Tring—also gave evidence on Thursday. He explained the signalling apparatus at Harrow and Wealdstone and the electrical and mechanical locking devices installed. Mr. Williams said that, immediately after the collision, he went to the signal box and checked the levers in the frame. He satisfied himself that the locking was effective, and checked the train indicators. Mr. H. A. Fishenden, telegraph inspector, also stated that the mechanical interlocking apparatus was functioning correctly and that the electrical devices, which were tested subsequently, were in order.

At the conclusion of the evidence taken on Thursday, Lieut.-Colonel Wilson announced that the inquiry would be adjourned until a later date. He went on to say that nothing could have been done by railwaymen or anyone else to prevent the second collision—by the Euston-Liverpool train—after the first had happened. Colonel Wilson then added that he was going to take a rather unusual step, in view of the great concern about the accident. The conclusions, he said, would be published in his report in due course ; but there was no doubt in his mind that the primary cause of the accident was that the distant signal at caution and the two stop signals at danger were run past by the Perth-Euston express at a speed which was difficult to estimate exactly, but which was certainly high. The line was equipped with modern block apparatus to assist the signalman and to prevent him from making mistakes. It must be asked whether any safeguard could be provided to prevent running past signals. Colonel Wilson went on to refer to existing systems of automatic train control and to experiments in which the Railway Executive had been engaged since 1948. The Railway Executive had now settled upon what it hoped would be a final prototype design. The unit apparatus, Colonel Wilson said, would be fitted in the immediate future on certain locomotives for trial under main line conditions.

Aluminium Vacuum Brake Cylinders

WE are informed by British Railways that experiments are being carried out with vacuum brake cylinders made of aluminium. Hitherto the vacuum brake cylinders used on both wagon and carriage stock have been made of cast iron, and these cylinders have always presented difficulties in manufacture and maintenance. In addition to the relatively long time taken in machining cast iron cylinders, difficulties are experienced in their maintenance due to the effects of corrosion in service.

In order to avoid the use of iron castings it was decided to experiment with cylinders pressed out of 14 gauge aluminium sheet. It was considered that this material, whilst permitting the cylinder to be manufactured economically as a deep-drawn pressing, would give a high degree of resistance to corrosion. To avoid the cost of expensive tooling in the initial development work, three cylinders were produced by spinning, and the closing disc was made from a casting. These two units were assembled in a standard drum with annular rubber gaskets between the mating faces to ensure a hermetical seal.

In the experiments on one complete assembly, which was subjected, on the test bench, to 100,000 complete cycles, no defects occurred. At the completion of the test a very small amount of detritus which was observed in the cylinder consisted, in the main, of powdered rubber, with a small amount of aluminium particles due to the removal of the " high spots " in the cylinder walls left from the spinning operation. This trouble, it is considered, would be completely obviated with a deep-drawn pressing.

A practical test is now in progress of two other cylinders fitted to covered goods vans operating on a scheduled run, to ascertain whether the results in actual service will be as successful as those on the test bench.

With the new design of cylinders, it is claimed that there is a substantial saving in man-hours in manufacture ; a saving in initial cost ; less maintenance will be needed due to elimination of corrosion ; no machining is required in construction except drilling ; there is additional strength due to a flange at the top preventing distortion; and there is a saving in weight related to the complete cylinder and case of approximately 12½ per cent.

The new cylinder was designed by Mr. E. Pugson, the chief officer, Carriage and Wagon Construction and Maintenance, Railway Executive, and the experiments connected with its production were carried out in collaboration with Wilkins and Mitchell, Ltd., of Darlaston.

A Nautical Equipment Showroom

ON Wednesday of last week, we were invited by Kelvin and Hughes (Marine), Ltd., to attend the opening of its service depot and showroom at 99 and 100, Fenchurch Street, London, E.C.3. The showroom itself has been designed as an attractive and comfortable centre wherein ship owners, marine superintendents and ships masters may see working the marine equipment which the company manufactures, and have its function explained by competent personnel. The service depot, apart from displaying an extensive range of nautical instruments which may be procured or inspected, provides servicing facilities covering chart correction, compass adjustment, radar and echo sounder service, as well as the customary repair service for all nautical instruments.

Transport and Productivity

By CHRISTOPHER T. BRUNNER

No. II—(*Concluded from page 528, October 17th*)

The presidental address to the Institute of Transport, from which extracts are here reprinted, was presented by Mr. Brunner on October 13th. Mr. Brunner is a director and general manager of Shell-Mex and B. P., Ltd., and his address was outspokenly critical of the failure of this country to devote sufficient capital to the improvement of its roads, railways, docks and airports.

Productivity in Road Transport

Insufficiency of Capital Expenditure on Roads.—The total expenditure on new road construction and major road improvements has amounted only to some £400 million since the beginning of this century, although the roads are the permanent way of a new form of transport which within that period has revolutionised the life of the community. This very modest expenditure on road improvement over the last fifty years compares with £600 million spent on the capital development of the electricity industry in the first six years since the end of the war. The result of inadequate capital expenditure on roads is that the vehicles which use them are denied the ease of movement needed for reasonable point-to-point speeds, for safety and for low running costs. A good deal of attention has been drawn to this during the past few years and, although much remedial action has been planned by the Ministry of Transport, very little has actually been undertaken due to the diversion of labour and materials to other purposes. Roads have, in fact, been given an extraordinarily low priority in the country's capital expenditure programmes, both on strategic works and on new industrial projects.

The reason is not far to seek. The operators of road transport, who have the biggest stake in the provision of a modern road system, have no say or influence in the matter except as ordinary citizens and voters. The level of capital expenditure on the roads is in the main determined by the central Government without consultation with the parties particularly concerned, and the initiative of local authorities has become increasingly circumscribed as their finances have grown more and more dependent on block grants from the central Government. This separation of the providers of the finance for the roads from the users is without doubt the main reason why so little has been done.

The first hurdle to cross is to educate those responsible for the road system to appreciate that, whatever their other uses, the roads are, from the economic point of view, a most important class of industrial equipment. It is difficult to see how this can be achieved unless steps are taken to link the road transport industry much more closely than has heretofore been attempted, with the provision of such an important part of its capital equipment. After all, the principal economic purpose of improving the road system is to reduce transport operating costs. The only rational economic approach to any proposed road scheme is to estimate the saving which would result from the road improvement and to compare it with the capital cost. It is a fundamental proposition in economics that the process of production is not complete until goods are in the hands of the final consumer. It is no picturesque metaphor to regard the permanent way of the transport system as an extension of the factory conveyor belt along which all goods must pass in their journey from the raw material stage to the finished product.

It is not necessary to look very far afield to find a much more advanced approach to capital expenditure on roads as a means of improving industrial productivity than that prevailing in Britain. Belgium, for example, a country whose industrial realism and ability to adjust her economy to changing circumstances have been outstanding since the war, is currently undertaking a five-year road modernisation plan of 1000 miles of route at a cost of £53 million. Belgium is also engaged on a fifteen-year programme for building 580 miles of motorways, linking up her principal cities and providing international links with neighbouring countries, at a cost of some £136 million. The purpose behind this scheme is to raise the level of industrial efficiency by providing a better transport system.

Other neighbouring countries, notably Holland and France, have done much over the same period to modernise their road systems; it is particularly significant that, in France, a new law has been passed by the National Assembly authorising special capital expenditure on road development and setting up a committee, including representatives of road users, to administer the highway funds allocated.

Need for Greater Capital Expenditure on Vehicles, Storage and Handling Equipment.—It is not only expenditure on roads which is required if road transport is to achieve greater productivity, but also capital expenditure on new vehicles and on storage and handling facilities.

Shortage of steel has resulted in an insufficient allocation to the motor manufacturing industry for capacity production, thereby increasing costs of production and reducing productivity. In the light of the need for maximum exports, this has entailed severe restrictions in the number of commercial vehicles coming forward for the home market. In consequence, many over-age vehicles continue to be used and to cause great waste of manpower because of their excessive need for repairs. Furthermore, many of the older vehicles have a smaller carrying capacity and are certainly less efficient mechanically than the vehicles with which operators would like to replace them and, in road transport as in other forms of transport, generally speaking, the greater the carrying capacity of the unit, the greater is the productivity per man-hour of the staff employed in operating it. The same arguments apply as with roads, and this country can only be the loser if her road transport fleet is older and less efficient than those of other countries with which she must compete for export orders.

Considerations of a like nature arise in the case of storage and handling facilities. The purpose of storage is to act as a buffer to ensure the smooth flow of goods through all the processes of production and distribution, and a buffer of the proper size both assists the smoothness and economy of the transport process and facilitates movements in large quantities which are cheap to carry. Adequate storage facilities are not a luxury provided for the purpose of simplifying administration, but a necessary part of the process of production and, if their provision is checked by difficulties in securing building licences and licences for materials for their construction, the whole flow of production is thrown out of gear, with particularly unfortunate repercussions on the efficiency of transport.

Economic Justification of Expenditure on Road Transport.—It is obviously necessary in a "crisis" economy, in which the price of capital is fixed at such a level that the Government can permit only a proportion of the economically justifiable capital expenditure projects to be undertaken, that some system of priorities should be drawn up for determining what capital expenditure should be undertaken at any particular time. This is a problem which might well occupy the thoughts of the professional economists to a much greater extent than hitherto. If capital were available at, say, 1 per cent over the Bank rate, and if there were no restrictions, either direct or indirect, on capital expenditure, then any project which could be paid off within twenty years would be economically justified. If the Government's crisis policy involves cuts in what might be termed the natural level of capital expenditure, how ought these cuts to be made? If a twenty years' pay-off is not favourable enough, then what is? Fifteen years, twelve years, eight years? No light has been shed on the proper answer to this all-important question. Many road projects can show a pay-off over an eight-year period or less. At what point is it in the national interest for these to be undertaken? The argument applies with equal force to expenditure on new vehicles and improved equipment. Given a proper priority for scarce materials, the initial outlay on new vehicles and equipment could be offset by savings in operating costs within a very short term.

Railways

Capital Expenditure Requirements.—The difficulties experienced by other forms of transport in making their full contribution to increased industrial productivity are in essence very similar to those described for road transport. The railways have a closely comparable problem of an elderly fleet of locomotives and of antiquated rolling stock, a similar need for strengthening their permanent way and perhaps particularly their bridges, while there is great scope for the extension of modern signalling methods. In the case of rolling stock, the provision of continuous brakes on all freight wagons would reduce substantially the difference in speed between passenger and freight trains and quicken the whole tempo of rail movement. The underlying operating principles are also the same as in road transport, viz., the use of the biggest unit practicable for moving freight, whether the individual wagon or the train, and the development of passenger transport in ways which will maximise the number of passenger-miles travelled per man employed, just as the bigger freight units will increase the number of ton-miles carried per man employed.

Achievement of increased productivity is not merely a question of minor improvements to the present system, but of fundamental changes comparable to the construction of motorways for road transport. Two such possible developments are the extension of electrification and the adoption of diesel traction over many parts of the railway system.

Other Means of Increasing Productivity.—There are perhaps two other directions of outstanding importance in which greater productivity can be achieved by the railways through alterations in equipment. In the first place, improvements can be made in the terminal services for freight traffic, particularly in handling, where there is scope for greatly extended use of mechanical aids; changes in the layout of depots would also offer advantages, for example, by facilitating the transfer of goods from rail wagons to road vehicles and thereby reducing the waiting time of both the transport units and the goods in transit. Secondly, duplication with road transport can be eliminated by the more rapid closing of small stations and the less important branch lines. A reduction of services to those points where road transport can handle both passenger and goods traffic more economically is not sufficient and, in the long run, only the final step of withdrawing the rail services completely can offer an effective remedy.

Water and Air Transport.

Obstacles to Increasing the Productivity of Water Transport.—It is not possible to view with any complacency the contribution to increased productivity which is being provided by the terminal facilities at the disposal of the shipping industry. Turn-round of ships is very slow, leading to unnecessary expense and to greatly reduced productivity on the part of the shipping industry itself. Slow turn-round is attributable to shortage and obsolescence of crane capacity at ports, and to lack or non-use of mechanical handling facilities at docks and warehouses. The docks themselves are over age, many having been built in the period of Victorian prosperity, and the facilities as a whole are inferior to those provided at the major competitive Continental ports, particularly those at the mouth of the Rhine which serve the great industrial areas of the Ruhr and the Low Countries. This is demonstrated by recent arrangements whereby ocean shipments of coal and grain to the United Kingdom have been routed via Rotterdam for

transhipment overside to British coastal vessels. Repairs are also slow, by reason of a long-foreseen shortage of dry-docking facilities which can only be remedied by new construction and new capital expenditure. In consequence, the number of days in the year when a ship is actually in service is well below pre-war standards. Appreciation of the danger of delays in port working is shown by the Government's recent action in setting up a Ports Efficiency Committee, which has itself encouraged the establishment of operations panels at main ports to ensure the most effective use of physical resources and dock labour.

The human element at the docks has also been something less than co-operative in its attitude to improved productivity and particularly great reluctance has been shown towards the adoption of modern methods of mechanical handling. There is a long history of casual labour and unemployment still fresh in the memories of a group which tends to be socially rather isolated from the rest of the community, and has of recent years been strong enough to slow down appreciably schemes for the modernisation of facilities which might have adverse repercussions on the employment, in their previous capacity, of any of its members.

The capital expenditure, however, which is most urgent arises from a change which has occurred in the balance between size of ships and cost of terminal facilities, in favour of using larger and faster ships for particular purposes and making them employable at a greater number of ports. So far as actual movement is concerned, since the cargo space of a ship varies as the cube of its dimensions while its resistance to the water varies only as the square of its dimensions, the larger ship is cheaper to propel per unit of cargo space than the smaller. The need is to increase the size of docks and jetties to accommodate bigger ships and to provide a sufficient depth of water for them. Here again we are dropping behind when compared with other countries and we simply cannot afford to do this.

Special Problems of Air Transport.—Air transport has a similar problem to sea transport, viz., the tendency for the size of the transport units to become bigger and for the cost of the terminal services to increase greatly as the size of the unit grows, with the consequent limitation of the employment of the largest aircraft to places where the traffic is heavy enough to warrant very considerable capital expenditure. Like sea transport, but, if anything even more marked, is the need to keep the transport units moving and moving fast for as many hours per month as possible. Air transport differs from sea transport, however, in the relative simplicity of the handling facilities required at terminals and the lack of opposition to their improvement. Like other forms of passenger transport, air transport becomes rapidly more profitable as the number of passenger miles flown approaches the number of seat miles flown and the productivity of air transport employees would be increased if the volume of traffic could be both expanded and evened out between one season and another. The rate and extent of this expansion must be related directly to the ability of the airline operator to provide less expensive air travel. It has been forecast that in a few years' time the great majority of passenger journeys of 200 to 300 miles or more will be by air and it is believed that there is a very considerable demand for quick, cheap transport from people who are quite unable to contemplate the current high fares, but who would willingly accept some form of tourist travel at lower fares. The recent decision to introduce tourist rates on some routes is sufficient proof of the revenue-earning possibilities of a development on these lines.

Perhaps the chief handicaps to air transport are, first, its occasional unreliability in respect of punctuality, particularly in the winter half of the year, a most serious drawback as its public consists predominantly of persons whose lives are especially regulated by the time factor and who must have the assurance of being able to keep fixed appointments in distant places, and, secondly, the delay between the time the passengers report to the air travel office and the time they become air-borne and vice versa. This latter is both a matter of organisation and administration in conjunction with the customs and immigration officials and also of the actual provision of new facilities, such as the ultimate use of helicopters between city centres and airports, from which very substantial time saving in the handling of passengers is anticipated; but, to the extent that some loss of time is inevitable, all possible steps should be taken to make it easy to pass the time at an airport as agreeably as possible. In this respect, our main airports fall far below the accepted standards of the rest of the world in both architecture and amenities. Expenditure on these would reap a rich harvest in passenger traffic; additionally, an important prestige element still attaches to air as the newest form of transport and, as for many thousands of visitors airports provide the first and the last impression of their stay here, they should do credit to our country.

Conclusions

Attitude of Management and Government.—It would be improper to distribute criticism without at least putting forward some tentative and perhaps constructive suggestions. Would it not be worth while to adopt a measure of decentralisation of initiative and decision on both sides? For instance, the case for turnpikes might be reconsidered. It is true, of course, that British road users pay enough in special taxation of their vehicles and fuel to entitle them to what ought to be the finest road system in the world, but that position has obtained for many years and has not resulted in the construction of a single mile of modern road. Is there not a case for allowing the local authorities and others interested, say, in the construction of a new road from Birmingham to South Wales, to form a turnpike trust with powers to borrow to enable the road and the Severn Bridge to be built on a public utility basis, which will permit of a toll being charged for such time as may be necessary to pay interest on the cost of construction, plus amortisation? Those directly concerned are much more acutely aware of the importance of action than is the central Government. Turnpike roads for which money has been provided in a comparable way have been financially successful in other parts of the world, notably in the United States, and have been the means of providing many fine new roads and bridges in that country. My suggestion is no more in essence than a restoration of the kind of local initiative which has often proved beneficial to this country in the past, for instance, in the building of the Manchester Ship Canal some sixty years ago.

Could not similar steps be taken to expedite the modernisation of some of our great ports upon which the lives and prosperity of whole communities depend? Perhaps a decentralisation of initiative in these matters and a closer link of local authorities with our big public utilities would lead to earlier and more effective action. The tentacles of an over-centralised Government in London have sapped to an incredible extent the local will to prosperity which has played such a big part in our past progress and is still a tremendously important factor in many other countries. This stifling of local effort must not be allowed to continue for ever.

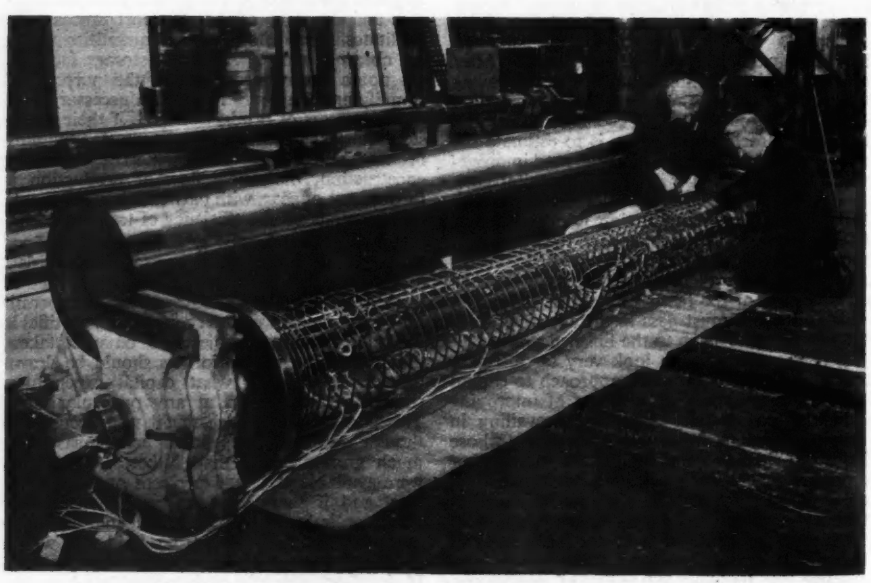
Decentralisation of initiative and decision is one of the fundamental principles of the administration of modern large-scale private enterprise. Is it so certain that the same principle ought not to apply in the case of Government, with its ever-growing interest in every facet of our economic life? These are but a few thoughts on possibilities which might be explored and on directions in which progress might be made. The present situation of frustration and of the progressive obsolescence of our transport system cries out for a search for new methods. It is not only the future of the British transport system, but the future of Britain as a major industrial power, which is at stake, unless positive steps are taken to break the present deadlock.

A Large Electrically Heated Roller

In the Hollinwood factory of Ferranti, Ltd., there is installed one of the largest resin-bonded-paper tube-making machines, which is capable of winding a laminated cylinder of resin-impregnated paper measuring 9ft in diameter by 12ft long. For the successful operation of this machine it is essential that the pressure roller, which is 12ft 6in long and has a diameter of 2ft, is uniformly heated so that it can maintain a temperature of 170 deg. Cent. to within plus or minus 3 deg. Cent. along the length of the roll. Another requirement is that there must be thermostatic general control within the limits of plus or minus 3 deg. Cent.

To fulfil these requirements a 30kW electric roller heater was supplied by Metropolitan-Vickers Electrical Company, Ltd., Manchester. To achieve such close temperature limits and avoid the heating up time being excessive, the heater was split into two main sections of 15kW each being distributed over the length of the roller. One of the sections was divided again into three, separately controlled, independent banks having 6kW, 3kW and 6kW loading respectively.

The tubular sheathed heating elements each



Construction of 30kW Heater

consist of a spiral of heat-resisting wire tightly embedded in a mineral insulator, and enclosed in an outer sheath of $\frac{1}{8}$in diameter non-scaling, non-corrodible alloy tube. The process ensures that the spiral is held in the centre of the bore so that a constant thickness of insulation lies between the sheath and the spiral. A fixed spider carries the elements, which can be seen in our illustration and which are arranged to give a higher heat output at the ends of the roller to compensate for the greater heat loss at these points and so ensure uniform heating.

Eeher radiation thermo-couples mounted on the haater spider measure the temperature of the internal roller face and maintain temperature control. Under test a high degree of uniformity of temperature has been maintained along the length of the roller, the maximum divergence being plus and minus 1½ deg. Cent., while no difficulty was encountered in maintaining general temperature control within the prescribed limits.

Mayurakshi Irrigation Project

(By our Indian Correspondent)

THE Mayurakshi River has a catchment area of 718 square miles above Messanjore, where the main impounding dam of an irrigation scheme is now under construction. The river rises in the hilly uplands of Santhal Parganas in Bihar and meets the Bhagirathi near Duttabati, in West Bengal ; in its course it is fed by various smaller streams, namely, the Brahmani, Dwarka, Bakreshwar and Kopai (in that order from north to south), and the network of these five rivers forms the main basis of the Mayurakshi irrigation project which is now nearing completion. The river is typical of those in the north-eastern part of India ; it is completely dry in summer, but during the monsoon it is in spate, overflowing its banks. It has a maximum recorded flood discharge of 106,280 cusecs measured in 1913. The main elements of the irrigation project are : a storage dam, 155ft high, at Messanjore ; Tilpara barrage on the river at Suri about 22 miles downstream of the dam ; a weir across the Bakreshwar and barrages across the Dwarka, Brahmani and Kopai, and 840 miles of canals including distributaries. The project is mainly an irrigation one, but it will be possible to generate about 2000kW of firm power with an additional 2000kW during the rainy season. The cost is estimated to be Rs. 15·50 crores (£11,625,000), the dam and the reservoir accounting for Rs. 5·17 crores. The irrigation canals command a gross area of over 1340 square miles, the net irrigable area being 605,000 acres for kharif crop and 120,000 acres for rabi cultivation. In addition, 25,000 acres of waste land are estimated to be reclaimed. All this will result in an increased yield of about 300,000 tons of rice and 50,000 tons of other crops such as wheat, potato and pulses, their total value per year being Rs. 4·6 crores.

With the exception of the dam, the foundation stone of which was laid by the Indian President on February 25, 1951, all major civil engineering works have now been completed. The dam, in rubble masonry, will be a little less than ½ mile in length at the top, of which the spillways will account for 740ft. It will normally hold water up to about 113ft above the sandy bed of the river and the freeboard of 10ft will bring the total height of the dam to about 155ft above the deepest foundation level. Although the highest recorded flood so far has just exceeded 100,000 cusecs, it is estimated that owing to the peculiar lie of the land the maximum peak flood may attain the figure of 300,000 cusecs, and the spillway has been designed accordingly. The reservoir will have a storage capacity of 500,000 acre-feet and at full reservoir level will cover an area of about 27 square miles. There will be three high-level and three low-level sluice gates, each 8½ft by 4½ft, which will be operated from the gallery inside the body of the dam. The spillways will have twenty-one sector gates, each 30ft in span and 15ft in height. The dam is expected to be completed by the summer of 1954.

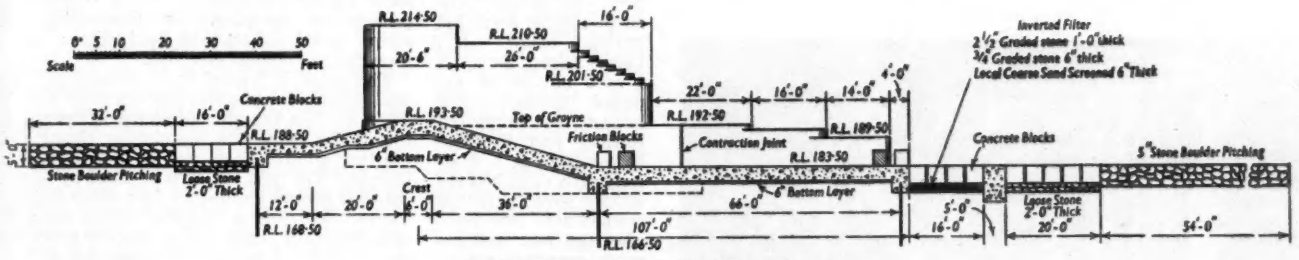
At the site of the Mayurakshi barrage at Tilpara, the river has a catchment area of 1239 square miles and a maximum " super-flood " discharge of 290,000 cusecs. The barrage comprises a weir, 1013ft long, with fifteen gates, each 60ft wide, with a head of 20ft, creating a pool along the river, nearly 5 miles long. The clear waterway of 900ft is made up of eight bays of 60ft each, four adjoining each bank, and seven central bays of the same span are designed to accommodate a flood discharge of 200,000 cusecs, against the maximum recorded discharge of about 175,000 cusecs. The foundations and the superstructure have, however, been designed to withstand a possible " super-flood " of 290,000 cusecs. The steel gates are 13½ft and 16½ft high in the central and the side bays respectively. The barrage foundation has been designed as a reinforced concrete raft from its upstream to its downstream end, which will also act as the impervious floor of the structure. The profile has a short crest width with upstream and downstream glacis having mild slopes with the usual floor lengths. The design was based on model experiments carried out at the River Research Institute, Bengal. Three lines of sheet piles constitute the cut-offs in the subsoil, one each at the upstream and downstream slopes, and act as a second line of defence in case of accidental damage to any part of the downstream floor. The foundation and protection works are designed to withstand a maximum static head of 26½ft measured from the lower downstream floor level to the top of the gates. Pier extensions and groynes have been used at the centre of each bay to provide for the necessary dead load on the downstream floor in order to counteract the residual uplift pressures. The piers are in rubble masonry faced with cement concrete blocks.

The construction of the barrage commenced in the early part of 1948 and was entrusted to B. R. Herman and Mohatta (India), Ltd. The sheet piling and floor up to crest level for nearly half the length of the barrage was completed when an untimely flood on May 12, 1949, put a stop to further work. (Monsoon in north-east India does not really begin until after the first week of June.) After a start in the winter of 1949–50, again interrupted by another heavy flood on June 12, 1950, the work was brought to a successful completion in March, 1951, by Engineers Syndicate (India), Ltd., which had taken over from the previous contractors. Lack of mechanisation commensurate with the size of the job was responsible for many irritating delays, and it was not until very late that sufficient machinery was imported from abroad, mainly for excavation work. Besides the difficulty in obtaining machinery, there was also a dearth of spare parts and suitable technical personnel, the latter problem having, however, been solved by the opening of a training centre at the site. The total estimated cost of the barrage is Rs. 1·22 crores.

Of the four minor barrages, the construction of the barrage on the Kopai River was taken up in 1950 and completed in March, 1952. It is 205ft in length with one head regulator controlling a maximum discharge of 1940 cusecs. The site is nearly 17 miles from the nearest railhead and the construction has consequently suffered from numerous delays owing to lack of communications. The existing weir over the River Bakreshwar is being remodelled to bring it in line with the overall design of the project. The weir will be 300ft long and the single-head regulator will cater for a maximum discharge of 2410 cusecs. The two barrages over the Rivers Dwarka and Brahmani are under construction and are expected to be finished by the end of 1953. They are 275ft and 415ft in length respectively, and will control maximum discharges of 1695 and 825 cusecs through their single regulators.

The total length of canals is 840 miles, of which the main canals account for 140 miles, the rest being branches, distributaries and minors. The total volume of earthwork involved is about 26 million cubic yards, most of it in soft rock. The excavation was commenced in the early part of 1948, but progress till 1949 was negligible. About 160 miles length of canals has now been excavated, involving just under 7 million cubic yards of earthwork. Excavation is being done partly by contractors and partly departmentally, both employing manual labour and machinery. So far, there are ten draglines and seven tractors and scrapers at work, and the total number of labourers in each of the last two seasons reached the figure of close on 10,000. The lining of canals will be undertaken later on after a few preliminary test runs. About 1200 masonry structures, such as siphons, aqueducts, falls and regulators are to be constructed. Of these, over 250 have now been completed, including a major reinforced concrete siphon on the main canal. Of the twenty-five railway bridges to be constructed, five had been completed by the end of 1951.

The entire area of the project is broadly divided into six blocks, separated by the five rivers ; the barrage over the Mayurakshi having now been completed, it is now possible to provide irrigation to the two blocks on each side of the river. From this an area of about 100,000 acres will be commanded for irrigation for the present kharif crop. This is one-sixth of the total ultimate area to be irrigated and marks the beginning of the slow process of development in a region which, with the Damodar Valley to the north and the Mahanadi (Hirakud project) to the south, bids fair to become one of the richest and the most highly developed in India.



Section Through Central Bay, Tilpara Barrage

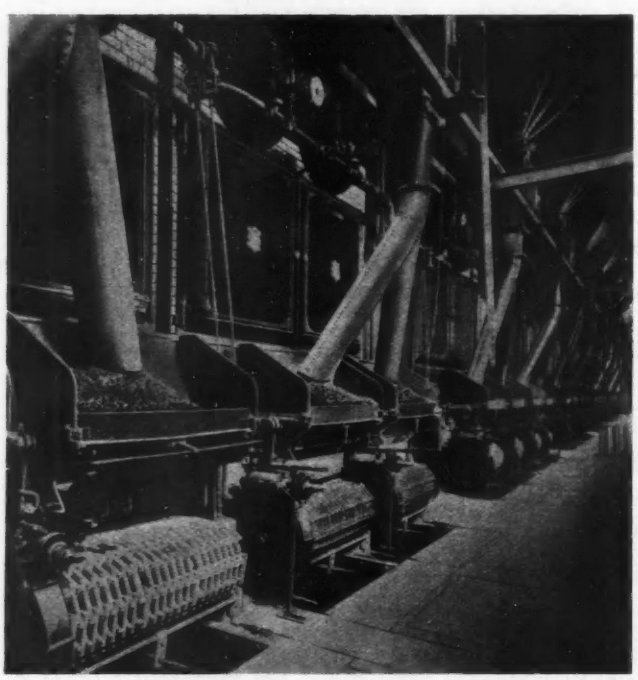
INSTITUTE OF METALS.—Professor F. C. Thompson, of the University of Manchester, has been elected president of the Institute of Metals for 1953–54. Major C. J. P. Ball and Professor G. V. Raynor have been elected vice-presidents.

University Courses for R.A.F. Technical Cadets

THE need for highly qualified technical officers in the Royal Air Force to deal with the problems created by the growing complexity of air warfare is being met in part by the introduction of university cadetships in the Technical Branch of the R.A.F., the first entry of which begin their training this month. These cadets, twenty in all, go first to the R.A.F. Technical College, Henlow, Beds, where they will spend a year being trained in the duties and responsibilities of an officer and will continue their scientific education to the standard of the qualifying examination for the Mechanical Sciences Tripos of Cambridge University. They will then go to a university for a three years' honours degree course and whilst there those who are medically fit for flying will also train as pilots with the University Air Squadron. Medical unfitness for flying or failure to learn to fly, however, do not debar otherwise suitable candidates from continuing their training as technical officers. After graduation cadets return to the R.A.F. Technical College for six months, where they are taught how to apply their professional knowledge to the particular requirements of the R.A.F. Technical cadets are selected each year in August by an R.A.F. Selection Board. Candidates are accepted between the ages of 17 and 19½ years (on July 1st of the year in which they compete for cadetships) and must be qualified educationally for admission to an English university.

Long Service Boilers

EIGHT boilers, out of the original eleven installed in the Bloom Street station, Manchester, are still operational after a working life of more than half a century. The boilers, which were made by Babcock and Wilcox, Ltd., originally supplied steam to reciprocating engines and then steamed a 10MW turbine set from 1917 until early this year when the set was scrapped and the boilers connected to the district heating service which has been in operation for more than forty years.



Firing Aisle, Bloom Street Station in 1901

The original complement of eleven boilers commenced operations in 1901 with four Musgrave engines of 3000 i.h.p. each, each boiler having a capacity of 18,000 lb per hour and being fired by Style 4 chain grate stokers. With a heating surface of 5137 square feet and 453 square feet of superheater they supplied steam at 160 lb per square inch and 90 deg. Fah. of superheat. In 1918 six boilers had the superheat surface increased to 880 square feet and since then some of the grates have been modified. All the grate driving mechanisms are still operating satisfactorily and tests taken in 1926 indicated a boiler efficiency of 71·4 per cent for the boiler alone.

Despite the fact that they have operated for many years on Manchester tap water, with the addition of a little caustic, the three boilers which have gone out of service have done so from external and not internal corrosion. Unlike the modern header boiler, where internal covers tend to tighten under pressure, these boilers were fitted with external caps which the boiler pressure tends to lift and at some time a weep was allowed to develop causing corrosion of the mud box. The future of the station has not been settled, but the remaining eight boilers will continue, no doubt, to supply steam to the heating system until more modern plant is installed to take over this duty. Our photograph shows the firing aisle of the Bloom Street station as it was in 1901. The station is now owned by the British Electricity Authority

The Future of the "Comet"

THE de Havilland Aircraft Company, Ltd., has recently explained its policy with regard to the production of the "Comet," now that the series 1 "Comet" has been in public service for five months and that the capabilities of the series 2 design are beginning to emerge from the trials which began on February 16th. Confidence in the practicability and economic value of jet propulsion in public transport is now becoming solidly established, and interest in the "Comet" has become more serious.

Only twenty-one of the series 1 and 1a (including the two development aircraft) are being built, and already production of the series 2 is getting under way. Larger sales of the series 1 were not to be expected because it was known that improved versions were likely to be available at a relatively early date, because airlines were fairly well stocked with new fleets after the war, and because operators needed convincing of the merits of jet propulsion.

A problem facing airlines, now that their confidence is growing, is whether to purchase the series 2 "Comet," a forty-four-passenger world airliner for delivery in 1954 and onwards, or to wait for a 58–78-passenger series 3 "Comet" in 1957, or for even later designs of the company.

The company emphasises that the rate of production of "Comets" has been in pace with the attitude of the operators, and that rate is actually considerably in excess of orders in hand. The degree of excess production beyond positive orders is a matter for most careful judgment, not only as a commercial risk, but also from the point of view of locking up productive facilities, effort and material, and thus delaying the introduction of the improved versions upon which Britain's technical lead in the future will depend.

The company believes that the British public, sensing the great opportunity which the "Comet" has undoubtedly opened up, is impatient for faster production to make good our present advantage. In practice, however, it is the demand from the operators which governs production. Trunk route airliners cost more than £500,000 apiece, and operators could not introduce "Comets" to replace good existing airliners unless assured of sufficient extra profit from the "Comets" to make good the premature write-off of their investment. On the other hand, world traffic is increasing and fleets must expand, and operators appreciate the need of gaining experience in jet propulsion with the "Comet 2," which, by reason of its 500 miles an hour cruising speed, achieves more work than a much larger piston-engined liner, while giving the travelling public the convenience of high-frequency service, in addition to its greater speed and comfort. It is realised that the "Comet 2" can be expected to give good service before it is superseded, and that the "Comet 3," like the "Comet 2," will outclass still larger liners that are not jet propelled.

The company maintains that it has developed and held in readiness schemes for rapid expansion when the orders justify it. Thus, as occurred recently, when an operator spoke of fifty "Comet 2s" in the year 1955, it undertook to supply that quantity in addition to orders already taken, provided a contract was placed without delay. The de Havilland Aircraft Company, Ltd., also offered to commence deliveries of the "Comet 3" late in 1956 and to supply at a rate rising to six a month in about two years.

A Multi-Duty Synchronous Process Timer

WE have received some particulars of an automatic multi-duty synchronous process timer which has been introduced by the Electrical Remote Control Company, Ltd., Harlow New Town, Essex. Essentially, the "M.A.P." timer consists of four component assemblies—a synchronous motor geared to give the required maximum timing period; an electromagnetic clutch with a timing disc which makes the equipment equally suitable for remote control and push-button operation; a time-setting and spring-loaded self-resetting mechanism; and a time dial and contact assembly.

The timer is housed in a rectangular sheet steel enclosure measuring approximately 6¾in by 5⅝in by 7½in overall. Mounted in the square top of the casing are the circular timing dial, the time control knob, and an indicator lamp, if fitted. The time setting is adjusted by turning the time control knob until the pointer indicates the required time on the dial, which has a 9in circumferential scale. The makers state that the accuracy of the timer is better than 0·5 per cent of full scale setting provided that the mains frequency is constant. The "M.A.P." timer can be supplied for maximum settings between 15 seconds and 30 days. The ratio of maximum to minimum time settings is about 100 : 1.

Operation of the timer can be initiated by closing the control circuit of the timer by any convenient means, such as an external push-button, a relay or a limit switch. As the timing period proceeds, a visual indication of the unexpired interval is given by the pointer as it moves towards the zero mark on the dial. When the timing operation is completed, the timer resets itself automatically, ready for the next operation.

Upwards of seventy different operational duties can be catered for, but the standard timer is arranged for six duty cycles, including the following: "make" for a preset time; "break" for a preset time; delayed "make" and delayed "break." The standard contacts have a switching capacity of 1A at 230V, a.c., but contacts with switching capacity up to 5A can be provided, and a further extension of capacity can, of course, be obtained by relays or contactors.

ALUMINIUM INFORMATION.—Under the title *About Aluminium*, the Northern Aluminium Company, Ltd., Banbury, has published a booklet which includes reprints of articles dealing with the specific physical and mechanical properties of the metal. The alloys are briefly discussed and heat treatment explained, and other sections discourse in general terms, upon, the mechanical, chemical, thermal and electrical properties of the aluminium alloys, while a final chapter reviews the growth of the industry.

Industrial and Labour Notes

Engineering and Railway Wages

On Tuesday last, representatives of the Engineering and Allied Employers' National Federation met the negotiating committee of the Confederation of Shipbuilding and Engineering Unions for resumed discussions on wages in the engineering industry. This meeting followed the talks which both sides have had recently with officials of the Ministry of Labour, and the undertaking then given by the unions not to impose the ban on overtime and piecework which the Confederation's executive had decided should begin on October 20th. After last Tuesday's meeting, it was stated that the employers had offered a wage increase of twopence an hour—an equivalent of 7s. 4d. a week. It is estimated that such an increase would cost the industry about £36,000,000 a year. The union leaders intimated that they could not accept the offer, but would put it, without any recommendations, to a conference of executives of the thirty-eight unions comprising the Confederation. As these notes go to press, representatives of the Shipbuilding Employers' Federation are meeting the union Confederation to discuss wages in the shipbuilding industry.

It was also announced on Tuesday that the Railway Staff National Tribunal had recommended a wage increase of 7s. a week to the railway workers represented by the three railway unions. The unions, it will be recalled, asked for a 10 per cent increase and for extra payment for Saturday afternoon and evening work. The claim was refused by the Railway Executive, which intimated that it was unable to make any offer. In giving its award, the Railway Staff National Tribunal had no recommendation to make about the claim for Saturday afternoon work. The Railway Executive is willing, however, to discuss with the unions any anomalies arising from the existing system of Saturday working.

Exports and Productivity

In an address to the Institution of Works Managers last Saturday, Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour, said that if top management expected loyal co-operation and hard work from its industrial team, it must not forget that to-day it had the inescapable duty of cutting its selling prices whenever that was possible. Only in that way, he urged, could we maintain our competitive position in export markets and bring down the cost of living at home. Mr. Watkinson agreed that to increase export earnings would not be easy, particularly in view of the increasingly severe competition which had to be met especially from Germany and Japan. Technically, he said, there should be nothing to fear from either of them because this country was some distance in front of both, but there might be cause for anxiety when prices and delivery dates were examined. Even after making every allowance for the reputation of British goods for quality and durability, it must be remembered that other factors might govern the acceptance or rejection of a tender. Prices obviously depended on production costs, and those costs were largely influenced by the levels of wages and productivity.

Mr. Watkinson went on to suggest that it might be helpful if there was less talk about productivity in vague terms, and if we examined industry and plant in terms of output per man-hour, for there, he thought, was the crucial test. High output per man-hour could pay good wages and yet compete in the markets of the world. The right way to meet the challenge of Germany and Japan was not by grumbling about it, but by increasing our margin of efficiency to counterbalance their margin of low wages and long hours. It was up to management, Mr. Watkinson continued, to show its own workpeople that it took them into its confidence and relied on them to join in the endeavour to secure an ever-rising level of efficiency and output. It must be brought home to everyone in industry, and accepted by the trade union movement as a whole, that high earnings could only come from high output. The Government also had a part to play in creating conditions in which efficiency could flourish and inefficiency be unprofitable. Mr. Watkinson said that he was convinced that this country was capable still of leading the world in research, applied science and engineering development. Given good management, willing and competent to make quick strides in the technique of production, and an equal keenness on the part of workpeople, there should be no cause for fear about our industrial future.

Work Study Training

The Department of Industrial Administration of the Birmingham College of Technology is organising a series of full-time courses on "The Practice of Work Study." It is stated that the aim of these courses is to establish a thorough understanding of the principles of work study through practice in an extensively equipped work study laboratory, through exchange of experience with teaching staff having many years of practical experience, and through observation of the introduction and management of work study in various industrial companies in the Midlands. An important principle which has been established and embodied in the planning of these courses is that the training of work study staff must not be conducted on narrow lines, but requires adequate support by instruction in subjects directly associated with the successful introduction of the work study technique.

Each course therefore provides 102 hours of instruction in industrial relations; factory organisation and production control; factory costing; communication; and the human aspects of management. It is emphasised that continuous practice of the work study technique in industry is essential if a man is to become qualified in all its aspects, and that the courses should be supplemented by such experience if they are to be fully effective. The courses, which will each occupy six weeks, are to be directed by Mr. Geoffrey P. Wade, B.Sc., A.M.I.E.E., and Mr. Victor N. Picken, A.M.I.E.E., and will be restricted to ten students training for or holding responsibility for work study in industry. Full details of them are available from the Department of Industrial Administration, College of Technology, Suffolk Street, Birmingham.

Industrial Change

The changes which have occurred in British industry during and since the war are commented upon in the latest issue of *Bulletin for Industry*, which is a monthly review of the economic situation prepared by the Treasury. The *Bulletin* explains that, in 1935, the metal and metal-using industries produced one-quarter of the total industrial output of the United Kingdom and, in 1948, more than one-third.

From 1948 to 1951, the *Bulletin* continues, the average annual increase in all manufacturing was 7 per cent, but the increase in vehicle building was 8 per cent, and in the large group incorporating engineering, shipbuilding and electrical goods, the annual increase was 9 per cent, whilst chemicals, including oil refining, increased by 11 per cent. In the post-war years, investment in the metal-manufacturing industries has been heavy and has been accompanied by only a small proportionate increase in manpower. But in the metal-using industries, the expansion of capacity has been more modest, though manpower has increased more rapidly than in the metal-manufacturing industries.

In commenting that expansion of iron and steel making capacity is one of the bases of industrial change, the *Bulletin* makes reference to the first post-war development plan of the iron and steel industry, which was approved in 1946, and to the progress of the work specified by that plan. Reference is also made to the second development plan which the industry is now formulating, and by which it is hoped to increase total output to at least 15,000,000 tons of pig iron and 20,000,000 ingot tons of steel a year. It adds that, "the achievement of such a plan would require extensive further investment in coke ovens, blast furnaces, open-hearth furnaces and rolling mills."

Finally, the *Bulletin* makes the observation that industrial growth is a continuous process. Its roots are in the laboratory and its sustenance is found partly in continued renewal and improvement of manufacturing capacity, partly in the initiative and adaptability of all ranks of the industrial army by its readiness to let new ideas and methods supplement new machines, or if necessary, for a time, be a substitute for them. The rate of industrial growth is the main determinant of Britain's future living standard and position in the world. Its speed depends upon how flexible the economy can prove itself and how big a share of resources the nation decides to set aside for this purpose.

Aluminium Price Increase

The Ministry of Materials has announced that, as from October 20th, the price of virgin aluminium in ingot form has been increased from £157 to £166 per long ton, delivered consumers' works, for metal of a purity of 99 per cent to 99·5 per cent inclusive. There is no change in the premiums which came into effect on July 1st for metal of higher purity and for metal in notch bar form. The Ministry says that it hopes to be able to keep the price at this level at least until April of next year.

Britain's Overseas Trade

The Board of Trade has now issued some more detailed figures of the United Kingdom's export and import trade in September, and has surveyed the trade situation during the third quarter of the year. It states that the value of exports during the third quarter was £574 million, compared with £628 million in the second quarter, and £718 million in the first quarter. The Board says that final volume index numbers of exports are not yet available, but the indications are that the volume of exports in the third quarter was about 5 per cent below the level of the second quarter.

The value of imports into the United Kingdom in the third quarter of the year was £788 million, compared with an average of £951 million over the preceding two quarters. Although import prices were lower during the third quarter than in the corresponding period of last year, there has been, at the same time, a substantial reduction in the volume of imports between the two periods. There was, for example, a fall in prices and a considerable fall in the volume of raw material imports, particularly in the third quarter of this year. Over the first nine months of this year, the Board of Trade statement continues, the adverse trade balance amounted to £654 million, which was £271 million less than the figure for the corresponding period of 1951. In terms of trade figures, therefore, there has been an improvement during the third quarter, effected solely, however, by a fall in imports which has more than counterbalanced the decline in exports.

The Board of Trade says that, although each of the broad categories of United Kingdom exports of manufactured goods was lower in the third quarter of this year than in the second, the decrease was not uniform. Exports of textiles declined by 22 per cent between the first and second quarters, but the decline between the second and third quarters, on a daily rate basis, was 12 per cent. Exports of metals and metal products, however, which on a daily rate basis were slightly higher in the second quarter than in the first, decreased by 19 per cent in the third quarter, while exports of engineering products, again on a working day basis, declined by 15 per cent in the third quarter compared with the second, as against a reduction of only 3 per cent between the second and first quarters. Exports of other manufactures also showed a higher rate of decrease between the second and third quarters than between the first and second, if the different number of working days is taken into account.

Notes and Memoranda

Air and Water

DIESEL ENGINE COOLING.—We have received a booklet entitled *Diesel Engine Cooling*, which has been issued by the Drayton Regulator and Instrument Company, Ltd., West Drayton, Middlesex, and is concerned with the use of automatic controllers in connection with oil engine cooling systems. Open and closed cooling systems are briefly mentioned and temperature controllers are reviewed, while control application is extensively dealt with and various schemes are illustrated by a number of diagrams.

"COMETS" FOR B.O.A.C.—The last of a fleet of nine Series I "Comet" aircraft for British Overseas Airways Corporation was delivered to London Airport on September 30th. This delivery was thus made fifteen months ahead of the contract date. Deliveries of Series 1A "Comets" to Canadian Pacific Airlines, Union Aeromaritime de Transport, Paris, the Royal Canadian Air Force and Air France will proceed during the ensuing months and deliveries of the Series 2 machine to B.O.A.C. will commence during the latter half of 1953. By the end of October, when the Corporation will be operating two services a week to Singapore in addition to its services to Johannesburg and Colombo, "Comets" will be flying more than 80,000 miles per week.

JET-RESISTANT ASPHALT CARPET.—A special carpet, applied on normal bituminous or tar-surfaced aprons or runway extremities where jet exhaust heat is likely to cause disintegration, has been proved over extensive trials in several countries to withstand heat and blast effects. This surface has been developed by Shell Petroleum Company, Ltd., St. Helens Court, London, E.C.3. The ugly scars to runways caused by certain jet aircraft—those with a comparatively low-slung exhaust orifice and acute angle of inclination to the ground—have lately become an urgent problem. Temperatures at the point of exhaust rise as high as 600 deg. Cent. (and perhaps 150 deg. to 200 deg. Cent. at runway level), with the velocity of the jet stream rising to 1800ft per second. Spillage of fuel has also been a cause of damage, particularly on refuelling areas, and here, too, the use of the new jet-resistant carpet shows marked benefits.

Miscellanea

MANAGEMENT TRAINING IN THE COAL INDUSTRY.—The National Coal Board has sent us a copy of a booklet which it has issued on its scheme for directed practical training for managerial positions in the British coal mining industry. The booklet, which is a guide to the working of the scheme, points out that the management of collieries covers a large and complex field. Training for it involves the detailed study of a variety of subjects.

FLAMEPROOF CABLE GLANDS.—Two new glands suitable for pliable wire-armoured cable have been added to the range of G.E.C. flameproof accessories. They have been certified for use with Group 1 gases by the Ministry of Fuel and Power Testing Station at Buxton, the certificate number being FLP. 825/2 when attached to G.E.C. (S 510) Flameproof Switches, and FLP. 1030/1 when attached to G.E.C. (S 512) Flameproof switch fuses.

THE EXCESS PROFITS LEVY.—The Federation of British Industries has published—at the price of one shilling—a booklet entitled *Guide to the Excess Profits Levy*. This booklet explains the major provisions of the legislation enacting the Excess Profits Levy, its purpose being to give a broad outline of the operation of the levy. It will be recalled that the tax is operative as from January 1, 1952. The booklet may be obtained from the Federation's offices at 21, Tothill Street, London, S.W.1.

E.H.T. CONCENTRIC CONNECTORS.—A brochure published by The Plessey Company, Ltd., Ilford, describes the full range of extra-high-tension concentric connectors made by the Company. Although these connectors are small, they are designed to have high insulation properties at extremes of temperature, and to pass high unmatched voltages without loss of characteristic. Two kinds are available: a demountable connector which is mainly for laboratory and prototype work, and a moulded connector which is intended for factory production.

CAUSTIC CRACKING IN STEAM BOILERS.—The Society of Chemical Industry is organising a symposium on "Caustic Cracking in Steam Boilers." It will be held at the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, on Thursday, November 20th, the morning and afternoon sessions beginning at 9.45 a.m. and 2 p.m. Seven papers—by British, American and Continental authors—are to be presented for discussion. Full details of the symposium can be obtained from the Society of Chemical Industry, 56, Victoria Street, London, S.W.1.

QUARTERLY JOURNAL OF MECHANICS AND APPLIED MATHEMATICS.—The September issue (Part 3, Vol. V) of the *Quarterly Journal of Mechanics and Applied Mathematics* (Clarendon Press, Oxford, price 15s.) contains articles by R. E. Meyer on "Waves of Finite Amplitude in Ducts"; by D. C. M. Leslie on "Supersonic Theory of Downwash Fields"; and by J. E. Phythian on "The Energy Distribution Behind a Two-Dimensional Shock," and on "Some Unsteady Motions of a Slender Body Through an Inviscid Gas." In the same issue R. Tiffen writes on "Boundary-value Problems of the Elastic Half Plane," and on "Solution of Two-Dimensional Elastic Problems by Conformal Mapping on to a Half-Plane."

FUEL DISTRIBUTION IN OXFORD.—On October 16th the bulk supply terminal, which has been built for Home Counties Petroleum Products, Ltd., was opened and came into full operation. Owned equally by the City Motor Company (Oxford), Ltd., and the Vacuum Oil Company, Ltd., this terminal at Botley Road, Oxford, will supply Oxfordshire and parts of the neighbouring counties. Road tank wagons with a capacity of 1200 or 2400 gallons and will be available for distribution purposes.

LAMPS FITTED WITH FUSES.—The General Electric Company, Ltd., states that all "Osram" general lighting service lamps from 40W to 300W, single coil, and from 40W to 100W, coiled coil, are now fitted with fuses, consisting of lengths of fuse-wire sealed in tiny glass tubes and incorporated in the two lead-in wires which carry the current to the filament. The purpose of the fuses is to minimise the risk of circuit fuses blowing, with the consequent inconvenience caused by other lamps on the same circuit being extinguished.

SPECIALISED FILMS.—We have received from Kinocrat Films, Ltd., Cromwell Road, London, S.W.7, a booklet which it has prepared on the use of motion pictures in industry and commerce. It contains much useful information about the making of 16mm and 35mm industrial films for general interest, instructional purposes and sales promotion. The section dealing with the initial requirements of film production—including technical liaison—is specially helpful as is also the information about the production costs of films.

ILLUMINATING ENGINEERING SOCIETY.—At the first meeting of the new session of the Illuminating Engineering Society, which was held on October 14th, Dr. W. J. Wellwood Ferguson took office as president for 1952–53. Honorary membership of the Society has been conferred upon Professor J. T. MacGregor Morris in recognition of his many services to the Society and in acknowledgment of his pioneering work in illuminating engineering and photometry. The Leon Gaster Memorial Premium has been awarded to Mr. J. S. McCulloch for his paper, entitled "The Lighting of Shipyards."

SHEET METAL USERS' CONFERENCE.—The annual autumn conference of the Sheet and Strip Metal Users' Technical Association will be held at the Grand Hotel, Birmingham, on Wednesday, Thursday and Friday, November 5th, 6th and 7th. The programme for the first day consists of works visits. The annual general meeting will be held at 9.30 a.m. on November 6th, and will be followed by the official opening, by the Lord Mayor of Birmingham, of an exhibition of sheet metal working equipment and techniques. The technical sessions for the discussion of papers are also included in the programme for November 6th and 7th. The honorary secretary of the Society is Mr. Alastair McLeod, 49, Wellington Street, Strand, London, W.C.2.

PACKAGED POWER.—A 16mm sound film in colour with a running time of 32 minutes has been produced as a review of the activities of the Aluminium, Ltd., group of companies, and is distributed by the Northern Aluminium Company, Ltd., Banbury. Entitled "Packaged Power," the film, by means of animated drawings and scenes photographed on site, shows how aluminium is manufactured. The film depicts bauxite being mined in British Guiana, chemically treated in Arvida, Quebec, to produce alumina and then reduced electrically to give metallic aluminium. Part of the film shows the ingots passing through a modern continuous strip mill at Rogerstone, South Wales, and includes views of the new mining and bauxite treatment plant in Jamaica, together with the hydro-electric developments in British Columbia, Canada, to supply power to the new aluminium smelter at Kitimat.

HEAVY-DUTY ELECTRIC TRAVELLING CRANES FOR IRON AND STEEL WORKS.—The specification for heavy-duty electric overhead travelling cranes in iron and steel works, published by the British Iron and Steel Research Association in May, 1950, has been revised and amendment slips are available, free, from the Association's information section, 11, Park Lane, W.1. The amendments relate chiefly to a reassessment of the forces arising from acceleration and braking and a closer definition of some permissible stresses; tolerances for standard crane couplings; provision of electro-magnetic shunt brakes with rectifiers on a.c. cranes; the provision of cross-travel conductors on certain cranes for subsequent fitting of magnets and the clarification of the main control gear layout diagrams. The amendment slips are gummed and perforated for insertion in the specification.

EMPIRE MINING AND METALLURGICAL CONGRESS.—Official publications for the Fifth Empire Mining and Metallurgical Congress, which is to be held in Australia and New Zealand during April and May, next year, will include a series of eight volumes in cloth binding. They will describe in an analytical and comparative manner the mineral deposits and the mining and metallurgical practices in Australia, New Zealand and surrounding territories. The titles of the volumes are as follows: *Geology of Australian Ore Deposits, Mining Methods in Australia and Adjacent Territories, Ore Dressing Methods in Australia and Adjacent Territories, Extractive Metallurgy in Australia, Australian Mining and Metallurgy, Coal in Australia, Handbook of Australia and New Zealand*, and *Proceedings and New Zealand Papers*. The planning of the Congress is being undertaken by a committee under the presidency of Mr. Essington Lewis, formerly chairman of the Broken Hill Proprietary Company, Ltd. Information is available from the Secretary, Fifth Empire Mining and Metallurgical Congress, 399, Little Collins Street, Melbourne, Australia.

BLAST FURNACE RELINING.—The United Steel Companies, Ltd., announce that the No. 9 blast furnace at the Appleby-Frodingham branch of the United Steel Companies, Ltd., has just been relined in the record time of twenty-four days. The furnace was taken off wind on September 27th. During the next five days there was very heavy rainfall and high winds so that the work of top stripping was made increasingly difficult. During the first thirty-six hours after the furnace came off blast, 426,000 gallons of water were put in to cool down the contents. As soon as the water was turned off demolition started, the total amount of rubbish removed from the furnace being about 3000 tons, in addition to several hundred tons of steelwork that had been dismantled and removed. Special railway lines were laid for conveying materials and the skips normally in use for charging the furnace with coke and ore were utilised for taking away old burden and bringing up new refractory brickwork. The hearth and bosh of the furnace have been lined with carbon blocks and the rest of the stack with refractory bricks. At the same time, the furnace hearth has been extended from a diameter of 22ft to 25ft, and it is estimated that this increase in size will produce an additional 600 tons of pig iron weekly on top of the normal 3800 tons.

BEILBY MEMORIAL AWARD.—From the interest derived from the invested capital of the Sir George Beilby Memorial Fund, at intervals to be determined by the Administrators representing the Royal Institute of Chemistry, the Society of Chemical Industry and the Institute of Metals, awards are made to British investigators in science to mark appreciation of records of distinguished work. Preference is given to investigations relating to the special interests of Sir George Beilby, including problems connected with fuel economy, chemical engineering and metallurgy, and awards are made, not on the result of any competition, but in recognition of continuous work of exceptional merit, bearing evidence of distinct advancement in science and practice. In general, awards are not applicable to workers of established repute, but are granted as an encouragement to younger men who have done original independent work of exceptional merit over a period of years. Consideration will be given to the making of an award or awards from the fund early in 1953. Outstanding work of the nature indicated may be brought to the notice of the Administrators, either by persons who desire to recommend the candidate or by the candidate himself, not later than December 31, 1952, by letter addressed to the Convenor of the Administrators, Sir George Beilby Memorial Fund, Royal Institute of Chemistry, 30, Russell Square, London, W.C.1. The letter should be accompanied by a short statement on the candidate's career and by eight copies of a list of references to papers or other works published by the candidate, independently or jointly.

Personal and Business

MR. J. C. W. HEDGES has been elected chairman of the Institute of Road Transport Engineers for 1952–53.

MR. J. V. CURRY has been appointed labour director of the North-Eastern division of the National Coal Board.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN announces the retirement of its general secretary, Mr. James Young.

MATTHEW HALL AND CO., Ltd., 26–28, Dorset Square, London, N.W.1, states that Mr. M. W. Sweetapple has been transferred to its Bulawayo office.

G. AND J. WEIR, Ltd., Cathcart, Glasgow, has purchased the foundries and certain ancillary departments at Newmains of Coltness Iron Company, Ltd.

MR. P. H. MUIRHEAD, C.B.E., and Major-General C. A. L. Dunphie, C.B., directors of Vickers-Armstrongs, Ltd., have joined the board of the parent company, Vickers, Ltd.

SIR WILLIAM ARROL AND CO., Ltd., Bridgeton, Glasgow, announces the election of Mr. John H. Huntley as chairman, in succession to the late Mr. Harry Cunningham.

A. C. MORRISON (ENGINEERS), Ltd., has now moved its offices and sales organisation to its factory at Cliff Works, Burton-on-the-Wolds, near Loughborough (telephone, Wymeswold 295).

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., states that Mr. R. Allen, A.M.I.E.E., has been appointed manager of the Birmingham district office in succession to Mr. A. F. Bock, who has retired.

THE Ministry of Labour states that Sir Robert Gould, chief industrial commissioner, has retired from the established service, but is continuing in a temporary capacity for a short period not extending beyond the end of the year. Sir Robert will be succeeded by Mr. H. G. Gee, C.M.G.

WOODFIELD HOIST AND ASSOCIATED INDUSTRIES, Ltd., Frindsbury Works, Rochester, announces that an agreement has been made with Dresser Equipment Company, Dallas, Texas, U.S.A., under which both companies are licensed to manufacture and sell "Ideco-Woodfield" oilfield equipment.

THE DAVID BROWN COMPANIES have acquired offices at 96, Piccadilly, London, W.1 (telephone, Grosvenor 7747), as their new London headquarters. For the present the London office of David Brown Tractors, Ltd., will remain at 49–50, Avenue Chambers, Vernon Place, Southampton Row, W.C.1.

British Patent Specifications

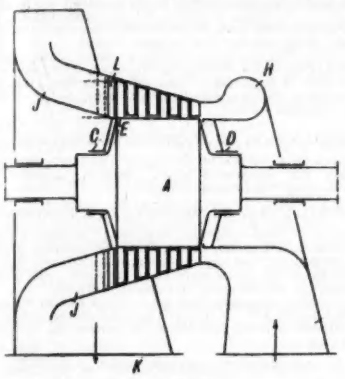
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

GAS TURBINES

679,602. March 8, 1951.—Gas Turbines, Gasturbine Maatschappij N.V., Surinamestraat 4, The Hague, The Netherlands. (*Inventor: Johannis de Beer.*)

The drawing illustrates a gas turbine with the outlet diffuser in cross-section, with four stages. *A* is the rotor on a shaft which is supported in two bearings. At *C* and *D* sealing packings are disposed. The rotor is provided with four rings of blades, in which *E* is the last movable ring of rotor blading. Between them are disposed the normal annular groups of stator blades, rigidly secured to the housing *F*. The inlet merges into the inlet casing *H*. The working medium passes through the diffuser *J* to the outlet *K*. Normally the gas enters after discharge



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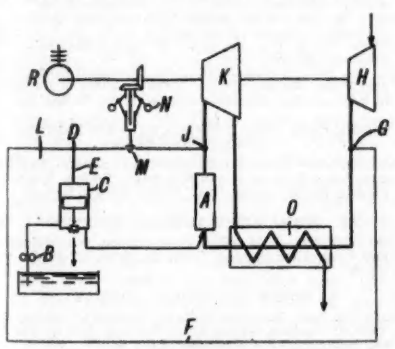
from the last ring of rotor blading *E* into the diffuser *J*. Then it enters at the tips of the blades into the gas flow with a deflection from the axial direction up to 10 deg. in the direction of motion of the blades, and at the root of the blades deflections up to 30 deg. in opposite direction to the motion of the blades; thus there is difference in direction of 40 deg. In order to get rid of this difference as much as possible the ring of additional guide blades *L* is provided after which there follows if necessary a second ring of guide blades *M* as indicated in dotted line, in order to reduce the divergence of gas flow from the axial direction, for example, up to at most plus or minus 5 deg. The additional guide blades *L* are given a twisted form about their longitudinal axis, in order to remove the inequality of the circumferential component of the stream as quickly as possible. Such a twisted blade gives to the gas stream a deflection varying over its length.—*September* 17, 1952.

680,667. May 3, 1951.—Method of Regulating Gas Turbine Plants, Maschinenfabrik Oerlikon, of Oerlikon, near Zurich, Switzerland.

The drawing shows one application of the invention to a simple, open, gas turbine cycle. The fuel to be supplied to the combustion chamber *A* is delivered by a pump *B* into a vessel *C* in which the level is main-



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tained constant by a float. The regulation of the fuel supply is effected by altering the pressure above the level of the fuel. For this purpose the vessel *C* is connected at *D* through a conduit *E* to a conduit *F* through which the control air is branched off at *G* beyond the compressor *H*) from the main air and led back at *J* in front of the turbine *K*. The point of connection *D* to the vessel *C* lies between a fixed orifice *L* and a regulating valve *M*, which is operated direct by a speed governor *N*. The pressure losses of the recuperator *O*, the combustion chamber *A*, and the conduits between *G* and *J* are used as the pressure drop for the control air. *R* is a generator coupled with the turbine *K*.—*October* 8, 1952.

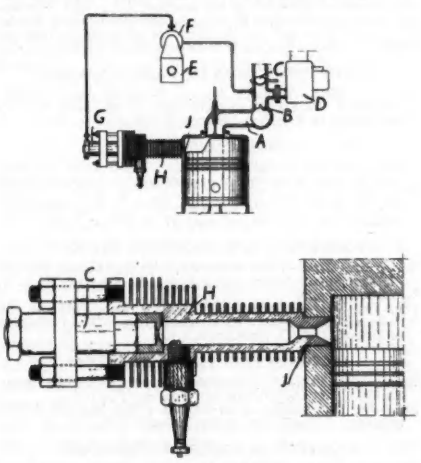
INTERNAL COMBUSTION ENGINES

680,643. December 9, 1949.—Reduction of Corrosion in Liquid-Cooled Internal Combustion Engines, William Doxford and Sons, Ltd., William Hamilton Purdie, Percy Jackson, M.Sc., all of Pallion Yard, Sunderland, and William Stewart Patterson, D.Sc., of King's College, Newcastle-on-Tyne.

The invention comprises improvements relating to the reduction of corrosion in metals exposed to the cooling water of internal combustion engines, in particular of marine engines. According to the invention, there is provided a liquid cooled engine having as the cooling medium a solution in fresh or distilled water of potassium dichromate and sodium nitrite. The cooling solution preferably contains 0·02 to 0·04 per cent of potassium dichromate and 0·1 to 0·4 per cent sodium nitrite. It is convenient in the preparation of the cooling medium to add the potassium dichromate and the sodium nitrite to the water in the form of an aqueous solution.—*October* 8, 1952.

679,516. June 12, 1950.—The Starting and Operation of Internal Combustion Engines, Rene Dufay, 4 rue Charles Morin, Seine-Inferieure, France.

Referring to the drawings, each cylinder is connected by an intake pipe *A* to an air intake *B*, having a choke valve *C*, and to a carburettor *D*. So as to allow the engine to operate on heavy fuel oil a heavy oil pump *E* controlled by a pressure regulator *F* is provided, the latter being connected to the air intake *B* on the cylinder side of the choke valve *C*. The pump feeds the engine through the intermediary of an injector *G*. For obtaining a sufficiently high ignition temperature, having regard to the low pressure of combustion of the engine, an auxiliary combustion chamber *H*, shown in the long view, is arranged between the injector and the cylinder head. For cold starting, the choke valve *C* is closed and the ignition and petrol supply are switched on. The carburised mixture furnished by the carburettor and sucked into the cylinder penetrates into chamber *H*, where it is ignited by the sparking plug. The engine starts on petrol and begins to run at low speed. As a consequence of the reduced air intake through the carburettor, the lowering of pressure is sufficient to maintain, through the regulator *F*, the pump *E* at rest. When it is estimated that the temperature of the chamber is sufficiently high, the petrol supply is cut off. The engine speed



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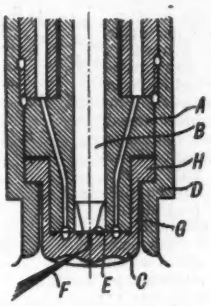
decreases and the pressure rises. The regulator then brings the pump into operation and heavy oil begins to be injected into the chamber, the sparking plug causing the ignition which, in consequence of the temperature of the nozzle *J*, occurs in the vicinity of the latter. During this stage of operation, air is supplied through the carburettor. If, subsequently, the choke valve is opened, the air intake increases, the pressure rises and the regulator causes an increase of the pump delivery. The speed of the motor increases, too, and the chamber *H* attains its normal working temperature, which is high enough to allow ignition of the heavy oil-air mixture without the help of the sparking plug, which may now be switched off. By acting on the choke valve *C*, it is possible to control, as in an ordinary diesel engine, the air intake and heavy oil injection. The operation of the motor is said to be very satisfactory the characteristic knock of diesel engines being suppressed.—*September* 17, 1952.

680,182. December 5, 1950.—Fuel Injection Valves for Internal Combustion Engines, Aktieselskabet Burmeister and Wain's Maskin and Skibsbyggeri, 4, Strandgade, Copenhagen.

As shown in the drawing, the fuel valve comprises a valve guide *A* with a valve spindle *B* and an atomiser plate *C* secured to the valve guide by means of a union nut *D*. The upper side of the atomiser plate forms a flat valve seat *E* co-operating with the lower end of the valve spindle and fuel injected through the



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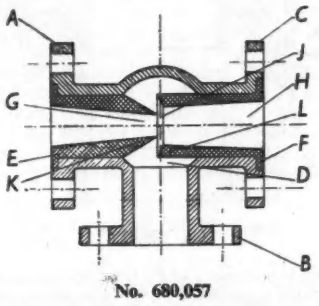
valve leaves the underside of the atomiser plate in the form of a number of jets, one of which is indicated at *F* on the drawing. As shown, the underside of the atomiser is wholly unobstructed, which is made possible by the atomiser being formed with a tubular sleeve portion *G* which encloses the lower end of the valve guide *A* and at its free edge is provided with a circumferential securing flange *H*. The sleeve portion *G* thus allows the supporting surface of the union nut to be located a considerable distance above the underside of the atomiser plate, so that the underside of the nut can lie at a higher level than the underside of the atomiser plate and the paths of the fuel jets *F* are not blocked on their way into the cylinder. The sleeve portion *G* has the further effect that it increases the rigidity against bending of the atomiser plate under the load on the valve seat during the operation.—*October* 1, 1952.

STEAM GENERATORS

680,057. August 1, 1950.—Promoting Water Circulation in Steam Boilers, Jose Antonio Perez Martinez, Barrio de Cataboy Freijeiro, Vigo, Spain.

The invention relates to an injector device for promoting water circulation in steam boilers. As shown in the drawing it comprises a casting having three



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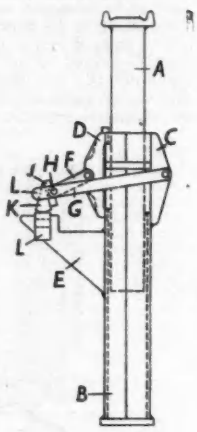
arms provided with connection flanges to the following parts, namely, part *A*, with the feed water inlet tube; the part *B*, with the suction tube having a flared end located in the lower part of the boiler, and the part *C*, with the discharge tube. Between these three parts is a spherical space or chamber *D*. The injector is fitted with two separate conical nozzles formed by aluminium-bronze linings *E* and *F*, having oppositely directed conical internal walls *G* and *H* between the ends of which is an annular space *J* for the admission of the water drawn in. The lining *E*, the internal diameter of which diminishes towards *K*, terminates, as shown, in a sharpened cone. In the lining *F* the internal diameter also diminishes towards *L*.—*October* 1, 1952.

MINING ENGINEERING

680,308. June 23, 1950.—Pit Prop, Becorit-Grubenausbau G.m.b.H., 11, Werkstaettenstrasse, Recklinghausen, Germany.

As the drawing shows, the inner prop member *A* is guided in the outer lower prop member *B*. On the head of the outer prop member is a fixed friction

insert carrier or pressure jaw *C*, which is opposed to a pressure jaw *D*, also provided with friction inserts on the side facing the inner prop member. The lower end of the jaw *D* abuts against a stop on the outer prop member. The outer prop member also carries at one side a supporting member *E*. The pressure jaws are connected with one another by a differential toggle lever pair, the shorter lever arm *F* being pivoted at one end with the pressure jaw *D*, and the longer lever arm *G* being connected at one end with the pressure jaw *C*. The levers are connected together at their other ends by the toggle joint *H* and form a small angle with one another. To set the prop, the toggle joint is pressed upwards and the inner prop member *B* is clamped between the jaws *C* and *D*. For removal the joint is moved down. In order to change the effective length of the longer lever arm *G*, the toggle joint can be displaced in the longitudinal direction. The joint is supported by a cross piece *J*, on the rear side of which is a wedge *K* which is tapered and bears against an inclined surface of the end portion *L* of the lever *G*.



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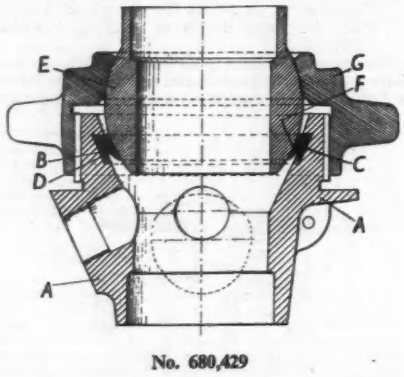
The base of the wedge *K* is supported on a horizontal wedge *L*. When setting the prop, the horizontal wedge *L* is driven inwards so that the wedge *K* is pressed upwards and the joint *H* is displaced sideways, whereby the effective length of the lever arm *G* is automatically adapted to the conditions. Only after reaching a certain resistance by the jaws *C* and *D* coming up against the inner prop member does the swinging of the toggle lever system and the clamping of the inner prop follow.—*October* 1, 1952.

TUBE AND PIPE COUPLINGS

680,429. December 24, 1948.—BALL-AND-SOCKET PIPE COUPLING, Joseph Hubert Gilles Leon Penasse, 530, Chaussee de Wavre, Etterbeek-Brussels, Belgium.

The object of the invention is to improve the fluid tightness of couplings mounted on compressed air and cold-water pipes subjected to a maximum pressure of 200 lb per square inch. According to the



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drawing, in the body *A* of the female coupling member is provided a groove *B* in which is partly lodged a ring-shaped rubber seal *C* of V-shape in cross section. The ring *C* has a lip *D* which projects from the groove *B* in such a way that its V cross-sectional shape provides a slit extending upwards between the lip and a base portion located in the groove. The rubber sealing ring thus has a lip which is pressure responsive and adapted to bear in a self-sealing manner against a ball *E*. The steel ball is placed against the inner circumferential face *F* of the lip *D* and is retained in that position by a cast steel clamping nut *G* which is screwed on the body until an intimate contact is produced between the ball and the nut. The ball bears against the spherical surface of the nut, on the one hand, and the lip on the other hand, and can therefore rotate with an easy friction fit, fluid tightness being ensured by the rubber seal.—*October* 8, 1952.

LAID-UP SHIPPING.—The Minister of Transport, Mr. Lennox-Boyd, has stated in a written reply that, excluding ships under repair, eighteen British ocean-going ships of over 1600 gross tons were laid up in the United Kingdom at the end of September, compared with two a year ago.

Launches and Trial Trips

SAXONHEATH, oil tanker; built by the Netherlands Dock and Shipbuilding Company for Stavros S. Niarchos, Bermuda; length between perpendiculars 535ft, breadth moulded 73ft, depth 40ft, deadweight 20,000 tons; one set of N.D.S.M.-Parsons turbine machinery, 7300 b.h.p., two N.D.S.M.-Babcock and Wilcox boilers, steam pressure 450 lb per square inch; service speed 14·5 knots. Launch, October 4th.

GRETAFIELD, oil tanker; built by the Furness Shipbuilding Company, Ltd., for the Northern Petroleum Tank Steamship Company, Ltd.; length between perpendiculars 496ft, breadth moulded 67ft 6in, depth moulded 36ft 5in, deadweight 16,500 tons on 29ft 1½in summer draught; twenty-seven oil cargo tanks, one pump room, two 400 tons per hour Duplex steam pumps, steam deck machinery, two 55kW steam-driven generators, one 25kW diesel generator; Hawthorn-Doxford single-acting, two-stroke oil engine, five cylinders, 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 112 r.p.m., two Scotch boilers. Trial, October 6th.

STYLEHURST, cargo liner; built by Swan, Hunter and Wigham Richardson, Ltd., for the Grenehurst Shipping Company, Ltd.; length between perpendiculars 435ft, breadth moulded 60ft, depth moulded to shelter deck 39ft 0½in, deadweight 10,000 tons on 26ft 5in draught, service speed 13¾ knots; five cargo holds, derrick complement includes ten 10-ton, one 50-ton and one 20-ton steam winches; Swan, Hunter-Doxford oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4400 b.h.p. at 115 r.p.m., two cylindrical multi-tubular boilers; two 35kW steam-driven generators and one 31kW diesel generator. Trial, October 7th.

NORTH KING, oil tanker; built by the Blythswood Shipbuilding Company, Ltd., for the Compania Petrolera de Transportes S.A. of Panama; length between perpendiculars 530ft, breadth moulded 72ft 9in, depth moulded 38ft 8in, deadweight 18,700 tons on 30ft 7in draught; twenty-one cargo oil tanks, two pump rooms, four 375 ton cargo oil pumps; Rowan-Doxford oil engine, burning heavy fuel, six cylinders, 700mm diameter by 2320mm combined stroke, 7300 b.h.p., two boilers, trial speed 15¼ knots. Trial, October 18th.

Contracts

HEAD WRIGHTSON AND CO., Ltd., Thornaby-on-Tees, has been awarded a contract by John Summers and Sons, Ltd., Shotton, Chester, for doubling the pig iron output of the plant at present under construction. Head Wrightson and Co., Ltd., is at present completing a plant at Shotton for the anticipated production of approximately 1000 tons of pig iron per day. This integrated plant covers the iron making equipment from ore unloading, crushing and screening through sintering to a complete blast furnace plant with gas cleaning equipment and special rolling stock. The new furnace plant wil be a duplicate of the one nearing completion.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., Oct. 28th.—Technical College, Wulfruna Street, Wolverhampton, "A Survey of Television Development and its Problems," H. J. Barton-Chapple, 7.15 p.m.

CHEMICAL SOCIETY

To-day, Oct. 24th.—ABERDEEN BRANCH: Robert Gordon's Technical College, Aberdeen, "Applications of Spectroscopy to Chemical Problems," W. C. Price, 7.30 p.m.——SOUTHAMPTON BRANCH: New Chemistry Building, The University, Southampton, "Atoms in Cages," H. M. Powell, 5 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Oct. 27th.—LEEDS CENTRE: Lighting Service Bureau, 24, Aire Street, Leeds, 1, "Lighting the Streets," H. E. G. Watts, 6.15 p.m.

Fri., Oct. 31st.—BIRMINGHAM CENTRE: Regent House, St. Philip's Place, Colmore Row, Birmingham, "The Evaluation of Lighting," R. G. Hopkinson, 6 p.m.

INCORPORATED PLANT ENGINEERS

Thurs., Oct. 30th.—S. YORKSHIRE BRANCH: Grand Hotel, Sheffield, "The Woodhead New Tunnel," 7.30 p.m.

Fri., Oct. 31st.—BIRMINGHAM BRANCH: Imperial Hotel, Birmingham, "The Tacoma Bridge Failure," 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

To-day, Oct. 24th.—Third Annual National Works Visits Day, South Wales.

Wed., Oct. 29th.—Waldorf Hotel, Aldwych, London, W.C.2, Sub-Committee T.S.35s illustrated report and film "Flow of Metals into Moulds," E. M. Currie, 7.30 p.m.

INSTITUTE OF ECONOMIC ENGINEERING

To-day, Oct. 24th.—Engineers' Club, Albert Square, Manchester, "Personnel Management," A. Cunliffe, 7 p.m.

Sat., Nov. 1st.—The Christian Institute, 70, Bothwell Street, Glasgow, "Time Study," J. Jones, 10.30 a.m.

INSTITUTE OF FUEL

Tues. and Wed., Oct. 28th and 29th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, Conference, "A Special Study of Ash and Clinker in Industry."

INSTITUTE OF METALS

Fri., Oct. 31st.—BIRMINGHAM LOCAL SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Discussion on "Aluminium *v.* Steel as Structural Material," 6.30 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Oct. 30th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, Presidential Address, Sir Charles G. Darwin, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., Oct. 30th.—WESTERN GROUP: Visit to Bristol Docks, 2.30 p.m., Grand Hotel, Bristol, "Air and Oil Filters," E. A. Stokes, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., Oct. 29th.—LONDON GRADUATES' AND STUDENTS' SECTION: Visit to A.I.O.C. Oil Refinery, Isle of Grain.

INSTITUTION OF CIVIL ENGINEERS

Tues., Oct. 28th.—PUBLIC HEALTH ENGINEERING DIVISION: Great George Street, London, S.W.1, "The Sardinian Project: an Experiment in Malaria Control by Species Eradication," John Logan, 5.30 p.m.

Fri., Oct. 31st.—YORKSHIRE ASSOCIATION: Great Northern Station Hotel, Leeds, "The Tinsley Sewerage Scheme, Sheffield," N. A. Pritchard, 7 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Oct. 27th.—RADIO SECTION: Savoy Place, London, W.C.2, Discussion on "The Impact of Television on Sound Broadcasting," opened by G. Parr, 5.30 p.m.

Tues., Oct. 28th.—LONDON STUDENTS' SECTION: R.E.M.E. Depot, Arborfield, Berks, "The Use of Working Scale Models in the Development of Broadcasting Aerials," 7 p.m.——S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Domestic Electrical Installations—Some Safety Aspects," H. W. Swann, 7 p.m.——N. MIDLAND CENTRE: Royal Station Hotel, York, "Economic Plant Sizes and Boiler Set Groupings on the British Grid," B. Donkin and P. H. Margen, 7 p.m.

Wed., Oct. 29th.—SUPPLY SECTION: Savoy Place, London, W.C.2, Chairman's Address, C. M. Cock, 5.30 p.m.——S.E. SCOTLAND SUB-CENTRE: Heriot-Watt College, Edinburgh, "Domestic Electrical Installations: Some Safety Aspects," H. W. Swann, 7 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Sat., Oct. 25th.—WEST OF SCOTLAND BRANCH: Engineering Centre, 351, Sauchiehall Street, Glasgow, "Flame Cutting and Welding Preparation," 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Oct. 24th.—GENERAL MEETING: Storey's Gate, St. James's Park, London, S.W.1, "The Design and Operation of Dunston 'B' Generating Station, with Particular Reference to 50 Megawatt Turbo-Alternators 'Unitized' with Reheater Boilers," A. Howell and J. H. Jackson, 5.30 p.m.

Fri., Oct. 31st.—GENERAL MEETING: Storey's Gate, St. James's Park, London, S.W.1, "Machine Tool Simplification, Especially as Applied to Horizontal Boring Machines," C. A. Sparkes, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., Oct. 25th.—WOLVERHAMPTON GRADUATE SECTION: Visit to B.S.A. Tools, Ltd., Marston Street, Birmingham, 9.30 p.m.

Tues., Oct. 28th.—LUTON SECTION: Town Hall, Luton, "Historical Development of Tube Manufacture," G. R. Goldsworthy, 7.15 p.m.——SHEFFIELD GRADUATE SECTION: Royal Victoria Station Hotel, Sheffield, "Optical Instruments Applied to Precision Measurements in Engineering," J. W. Harrison, 6.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Oct. 24th.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Birmingham, Chairman's Address, H. J. Morris, 6 p.m.

Mon., Oct. 27th.—SCOTTISH BRANCH: Ca'doro Restaurant, Union Street, Glasgow, "Aluminium in Structural Engineering," M. Bridgewater, 6 p.m.

Wed., Oct. 29th.—LANCASHIRE AND CHESHIRE BRANCH: Reynolds Hall, College of Technology, Manchester, "Reinforced Concrete Structures in Coke Oven Plants," John Drinkwater, "Some Useful Graphs for the Design of Foundations," J. W. White, "Secondary Effects of Details on the Stresses in Structural Steelwork," R. W. Williams, 5.45 p.m.——WALES AND MONMOUTHSHIRE BRANCH: Mackworth Hotel, Swansea, Chairman's Address, R. D. Heseltine, 6.30 p.m.

Thurs., Oct. 30th.—YORKSHIRE BRANCH: The University, Leeds, Chairman's Address, D. R. S. Wilson, 6.30 p.m.

IRON AND STEEL INSTITUTE

Tues., Oct. 28th.—4, Grosvenor Gardens, London, S.W.1, Meeting in conjunction with the British Iron and Steel Research Association to discuss papers on "The Corrosion of Steel under Phosphate Coatings and Protective Finishes," 2 p.m.

Thurs., Oct. 30th.—IRON AND STEEL ENGINEERS GROUP: 4, Grosvenor Gardens, London, S.W.1, "Electric Drives for Continuous Hot Mills," G. R. Wilson, 10.30 a.m., "A New Hot Mill for Strips up to 24in wide," M. Langen, 2 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Oct. 24th.—Townsend House, Greycoat Place, London, S.W.1, "Coin Manufacture," G. H. Thompson, 7 p.m.

Sat., Oct. 25th.—N.W. SECTION: Geographical Society, 16, St. Mary's Parsonage, Manchester, "The Story of the Earth, Some Geo-physical Features and their Applications," N. Brookes, 2.30 p.m.

Fri., Oct. 31st.—INFORMAL MEETING: Townsend House, Greycoat Place, London, S.W.1, "Some Problems in the Design of Motion Picture Sound Equipment," W. C. C. Ball, 7 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Oct. 31st.—Literary and Philosophical Society, Newcastle upon Tyne, Parsons Memorial Lecture, "From Stodola to Modern Turbine Engineering," Claude Seippel, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Oct. 30th.—4, Hamilton Place, London, W.1, "Temperature Control for Pressure Cabin Jet Aircraft," E. W. Still, 7 p.m.

ROYAL STATISTICAL SOCIETY

Wed., Oct. 29th.—RESEARCH SECTION: School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, "Sequential Estimation," F. J. Anscombe, 5.15 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Tues., Oct. 28th.—Grand Hotel, Sheffield, "Recent Research in the Deformation of Metals," R. W. K. Honeycombe, 7 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Oct. 28th.—Manson House, Portland Place, London, W.1, "The Design of Sliding Contact Assemblies in Instrument Applications," D. O. Walter, 7 p.m.